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I. THE ETHEREAL HYPOTHESIS OF LIGHT.

By James Samuelson, Editor.

The thirst for knowledge in the human mind is as insatiable as the wants of an immortal soul are necessarily unlimited. There are indeed myriads, content to go their daily rounds and confine their inquiries to the price of corn, cotton, consols, or whatever staple may serve to provide them with the necessaries and luxuries of life; but there are nobler men than those, who would rather be the discoverers of a secret in nature that yields wealth to thousands, than one of the ignorant thousands who reap the fruits of their researches; and of such men none have shown themselves more disinterestedly devoted to their intellectual calling than the students of physical and chemical science. Indeed it is almost to be regretted that they are not a little more worldly, for in that case their scientific theories and speculations would probably rest upon a more material basis than they sometimes do at present. Amongst the numerous subjects which are now engaging the attention of physical philosophers, there is none, perhaps, of deeper interest either to scientific men or to the lovers of the mysterious in nature, than that which relates to the illimitable space, wherein the universe of suns and planets moves incessantly, which serves as the medium to convey intelligence from sphere to sphere, and to communicate life from the great centres to the surrounding orbs. But it is rather as a curious inquirer, than with any pretensions to original research; rather in the hope that my observations and criticisms may stimulate discussion and cause further investigation, than with any expectation that they will throw fresh light upon so difficult and obscure a cosmical inquiry, that I propose its consideration in the present article.

There are in the present day two distinct theories in relation to light, arising not from any difference of opinion as to the action of

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that force, inasmuch as the undulatory theory is now pretty generally accepted, but from opposing views as to the medium upon and through which it operates. It is needless for me to dwell long upon the undulatory theory, but, for the government of those who have not devoted much attention to the subject, it may be as well to mention that formerly light was not regarded as a force acting upon matter, but was supposed to consist of particles or atoms emitted by the luminous body, whilst electricity was considered an imponderable fluid which travelled through the substances electrified. Now, strangely enough, the views of the more advanced physical philosophers are to some extent reversed. Mr. Grove considers the electrical spark, at least, to consist generally of projected particles of the electrified substance,* and he gives apparently satisfactory reasons for so doing, whilst Professor Tyndall thinks that electricity may be a force acting upon "condensed ether which surrounds the atoms" of matter.† And on the other hand, as we shall presently find, the latter entirely discards the notion of any known substance as the vehicle of light, whilst Grove considers it to be a force acting upon gross but highly attenuated matter. But as I have already said, all are agreed upon the dynamical theory of light, first propounded by Huyghens in Newton's time, and afterwards supported and established in this country by Dr. Young; and this theory attributes to light a similar, though not exactly the same property, as sound, regarding it as a force which causes undulations of marvellous rapidity in the medium through which it travels. In the case of sound, the passage of the force is admitted on all hands to be through known matter, and it is well known that a vacuum is incapable of transmitting sound; but in that of light, which passes from sphere to sphere in the universe, and traverses a vacuum with apparently greater facility than air, it is obviously necessary either to discover or to suppose a medium for its transmission. That there is such a medium in interplanetary space is most probable, for light occupies *time* in its passage, corresponding with the distances between the luminous bodies from which it emanates and the spheres it illuminates, and therefore (in the case of our sun and earth for example) it cannot be the atmosphere alone which offers resistance to its passage. There is most likely matter of some kind, however attenuated, in space; and this is shown, not alone by the impeded passage of light, but by the retarded motions of the comets.

But what is that interplanetary matter?

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* "The electric spark, the brush, and similar phenomena, the old theories regarded as actual emanations of the matter or fluid Electricity, I venture to regard them as produced by an emission of the material itself from whence they issue, and a molecular action of the gas, or intermedium, through or across which they are transmitted."—'Correlation of Physical Forces and Continuity,' p. 112. 5th edition. Longmans: see also p. 181.

† 'Heat as a Mode of Motion,' p. 216, note. 2nd edition. Longmans.

Is it, as Professor Tyndall supposes, a specific "ether," which serves as the vehicle for light and electricity? Does it enter, as he believes it does, into the constitution of material bodies? or is it excluded beyond the limits of our atmosphere? Or again, is it, as Mr. Grove believes, an attenuated gas or mixture of gases, given off from the atmospheres of the revolving worlds?

Let us first endeavour to understand the conceptions of these opposite thinkers, and then to test their respective hypotheses by the best means at our command. Professor Tyndall's conception of a "luminiferous ether" is that it is "a substance almost infinitely elastic," filling all space as with "jelly."* It fills up the interstices between molecules of all kinds of matter, "suffering no rupture of continuity at the surface of the eye, the intermolecular spaces of the various humours being filled with it."† He believes it to form the infinite ocean in which worlds move, and to be the medium for the transmission of light there, as well as in the intermolecular spaces of material substances—in short he regards it as the medium for the transmission of light—(and probably of electricity) *everywhere.*

Mr. Grove objects to this idea of a *specific* ether, both for the transmission of light and electricity.‡ His views concerning the latter force we have given generally,§ and his ground for refusing to accept the doctrine in regard to light is, that "the more porous bodies, or those most permeable by ether, *should be* the best conductors,"‖ and that "an objection immediately occurs in the opacity of porous, and transparency of certain dense bodies.¶ He believes in the universality of ordinary matter, however attenuated, and considers his hypothesis "the least gratuitous."**

There are other writers, who, seeking to reconcile these opposite views, suppose that the ether does *not* penetrate our atmosphere, being "non-miscible" with it, and that therefore it does not permeate terrestrial matter.††

This hypothesis may be at once dismissed, for if the supposed ether is not miscible with our atmosphere, then the latter should itself be the medium upon which light operates; therefore the first stroke of the piston of an air-pump should cause the receiver to darken, and an object in an exhausted receiver should be invisible, just as the sound of a bell striking therein is inaudible. In the present state of the discussion and of our knowledge, therefore, we are left to consider the respective merits of the two hypotheses, which for convenience I shall call those of Grove and Tyndall;* and in order to guide the students of various branches of physical science in their investigations, I propose, first, to select a few phenomena for the consideration of the micro-zoologist, chemical and physical experimenter, and mineralogist, and then to point out what appears, in my humble judgment, to be the inference deducible from those phenomena, leaving it to each class of observers to consider the value and accuracy of my investigations, and of the conclusion to which I have been led by them.†

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* 'Heat as a Mode of Motion,' p. 254.

† 'On Radiation,' p. 9. Longmans.

‡ 'Correlation and Continuity,' p. 133–4.

§ They will be found detailed in the chapter on "Electricity" in his work on the 'Correlation of the Physical Forces.'

‖ 'Correlation,' p. 148. ¶ Ibid., p. 168. ** Ibid., p. 186.

†† Brooke's edition of Golding Bird's 'Natural Philosophy.' Sixth edition, p. 576. Churchill.

First, then, it is familiar to all who have any knowledge of natural history that the brilliant hues of the Lepidoptera, or Butterflies, are due to innumerable minute scales, regularly disposed upon their wings, just as the feathers of birds impart the bright colours to those races. In certain butterflies the wings have an iridescent, or metallic lustre (*Lycœna Adonis,* the Clifton Blue); in others it is dead and velvety (*Vanessa Io,* the Common Peacock); whilst in others again, both appearances are intermingled (*Polyommatos Phlœas,* the small copper). Now let us inquire to what cause this phenomenon is attributable.

We will take a specimen of *Lycœna Adonis,* the Clifton Blue, of which the blue is quite metallic, or satiny, if I may be allowed to coin the word, and on placing a few of the scales of this insect under the microscope and examining them by transmitted sunlight, that is, by light reflected from the mirror and transmitted through the scales to the eye, we shall find certain of them quite crystalline and transparent (see Plate, Fig. 1); others bright orange-red (Fig. 2); and others again dusky brown, almost approaching to black.

Now let us close off the light reflected from the mirror and examine the same scales by incident light, that is, by light concentrated upon them with the aid of the bull's-eye lens, and we shall find those which by transmitted light appeared translucent and colourless (Fig. 1) to be greenish brown or grey, studded with bright spots (Fig. 1a); those which were orange-red by transmitted light (Fig. 2) now appear of a brilliant violet-blue (Fig. 2a), the characteristic blue of the wings themselves; whilst the dull brown scales (Fig. 3) are the least changed of any, being rather lighter (Fig. 3a) and presenting a steel-like surface.

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* I call the "ethereal" theory Professor Tyndall's, inasmuch as he has sought to develop it; but those who are interested in its origin and history may refer to that author's work, 'Heat as a Mode of Motion.' Professor Faraday appears to have given a cautious, or perhaps I should say partial, adhesion to the theory; and he refers to it once or twice in passing, in the Bakerian Lecture of 1851, which I shall quote freely in this article. See also Tyndall's 'Faraday as a Discoverer,' p. 129. Longmans.

† Mr. Clerk Maxwell, it may be mentioned, considers "light" as a mode of electro-magnetic motion. He says, it "consists of alternate and opposite rapidly recurring transverse magnetic disturbances, accompanied with electric displacements, the direction of the electric displacement being at right angles to the magnetic disturbance, and both at right angles to the direction of the ray." (Proceedings of the Royal Society, 1864.)

The cause of these changes is quite obvious.

In the scale which was translucent and colourless by transmitted, but brownish-grey under incident light, a portion of the ray (as I shall for the present call it) is reflected back to the eye in the latter condition; that is to say, whilst it passes unimpeded through the scale in the first instance, it is arrested in the second, being partly absorbed and partly reflected. In the scale which appeared differently coloured under both aspects, namely, red by transmitted, and blue under incident light, the ray was arrested in both instances, the same part, namely, the orange-red passing through, and the other (the blue) being reflected. In the first instance, we saw the ray which had passed; in the second, that which was unable to pass, but which was reflected. (It must always be borne in mind that for the present I speak popularly, for we shall presently consider what "ray" and "portion of ray" really mean.) In the third example (3 and 3a) there is secreted in the scale itself a substance which has the power of arresting certain rays when the light enters from above (incident) less than when it strikes upwards from below (transmitted). Because, in the first instance, the scale surface arrests and reflects a portion of the light before even it enters the scale, as exemplified also in Fig. 2a, or perhaps more characteristically still in another species, *Lycœna Alexis*, where the scale is pale brown (also caused by pigment) by transmitted, and pearly opal (Fig. 5) under incident light. In the "Admiral" (*Vanessa Atalanta*) the effect is as nearly as possible the same under both conditions, the colour being due to pigment, Fig. 4.*

Deferring for a time the consideration of the bearing of these phenomena upon the ethereal hypothesis, I will now direct the reader's attention to the results of a few of the elaborate and interesting experiments of the late Professor Faraday, connected with "the relations of gold and other metals to light." These were fully recorded in his Bakerian Lecture, 1857, and printed in the 'Philosophical Transactions' for that year; and a careful perusal of his observations, and if possible a repetition of his experiments, will well repay the student for his labour. He found that gold-leaf by transmitted light is green; by incident light, yellow, and of a metallic lustre.

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* In order to ensure accuracy as to the *cause* of the colour in these scales, I enlisted the aid of my friend Dr. Frankland, to whom I sent portions of the wings and scales corresponding with those which I had submitted to microscopical investigation. He bleached, or tried to bleach them with Peroxide of Hydrogen, and with Chlorine water, and the result was generally, as I had anticipated. The brown scales bleached easily and completely; the blue ones only turned pale green. After describing to me the different reactions, Dr. Frankland said:—"Judging from these experiments as well as from the appearance of the wings, I should say that the blue scales owe their colour in every case to interference, whilst all the rest are tinted with pigments."

"When gold-leaf is laid upon glass, and its temperature raised considerably without disturbance, either by the blow-pipe or an ordinary argand-burner, it seems to disappear, *i. e.* the lustre passes away, the light transmitted is abundant and nearly white;"* but "when gold, rendered colourless by annealing, is subjected to pressure, it again becomes a green colour," . . . . and "the green colour can be again taken away by heat to appear again by renewed pressure."† Again, gold in a minutely divided condition caused by deflagration, *transmitted* violet, green, or ruby rays; but by *reflected* light "it is golden and metallic."‡ "It is evident that all the colours described are produced by one and the same substance, namely, gold, the only apparent difference being *the state of division* and different degrees of the application of heat;"§ . . . "and I think I am justified by my experiments in stating that fine gold particles so loosely deposited that they wipe off by a light touch of the finger, and possessing one conjoint structure, can in one state transmit light of a blue-grey colour, or can by heat be made to transmit light of a ruby colour, or can by pressure from either of these former states transmit light of a green colour, all these modifications being due to gold as gold."‖ That it is the disposition of the particles which causes the modifications of colour is further shown by the author, when he says¶ that thin films of gold prepared by phosphorus give "a feeble grey-violet" by transmitted light; if the films are a little thicker they give "a violet;" but "superposition of several grey-violet films does not produce a green tint, but only a diminution of light without change of colour." Yet it will be remembered that a sheet of gold-leaf gives a bright green.

Another result of Faraday's observations is that vapours and gases will pass through these films;** and their appearance with a power of 700 linear is reported to be "slightly granular."††

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* 'Phil. Trans., 1857,' p. 148.

† Ibid., p. 149. It may be as well to mention here what Faraday thought in relation to the cause of the change. At p. 149 he says:—"As to the essential cause of this change of colour, more investigation is required to decide what that may be. As already mentioned, it might be thought that the gold-leaf had run up into separate particles. . . . On the whole I incline to this opinion." Let me add in reference to these remarks of Faraday, that on examining with a microscope some "gold bronze," which I know consisted of very fine particles of gold, I found that by transmitted light they gave in the mass a yellowish-red colour, and each particle precisely resembled minute flakes of crumpled gold-leaf; but when I subjected the dust to pressure between two sides, not alone each particle, but the whole aggregation of them assumed the characteristic green hue—the change being, however, more apparent in the individual particles.

‡ Ibid., p. 152. § Ibid., p. 153. ‖ P. 153. ¶ Pp. 155–6.

** "Experimentally, also, I find that vapours and gases can pass through them," p. 156.

†† P. 157

After reading the account of Faraday's beautiful and exhaustive experiments,* of which I have only referred to one series, I should have despaired of being able to add any information that would elucidate our inquiry had not nature herself prepared a beautiful microscopical object, which, in common with many friends, I have examined with undiminished pleasure and admiration for nearly twelve years.

It is called the "Sonnenstein," or Sun Stone, from its peculiar brilliancy, and is found in Arendal in Norway. Its brightness is due to innumerable minute metallic crystals imbedded in a matrix of a translucent substance of a spar-like nature. Examined with a low power by transmitted light, it resembles a colourless transparent fragment of glass or spar, containing irregularly-shaped pale, orange, and red translucent crystals (Fig. 6); where these are superposed one above another, they assume a brighter hue; but when viewed by incident light an almost miraculous transformation takes place, some of the crystals appearing bright blue, others presenting every colour of the spectrum, and if the object be turned slowly round the same crystals reflect different hues as they revolve.† The transparency of the matrix is due to its extreme tenuity (the object having been cut with the aid of a mechanical contrivance, by the late Dr. Oschatz of Berlin), and viewed with a higher power under incident light in one position, the light is reflected from its surface, which is then opaline (Fig. 6a), and the imbedded metallic crystals are invisible. As to the dimensions of my little preparation, it is difficult to form a correct idea of them. In the Plate (Fig. 6 and 6a) the whole object is magnified about 5 diameters, or about 25 times in superficial area: but from the mode in which it is mounted between sheets of glass above and below (the former being a combination of two slips, flint and crown, I believe), it is impossible to form an accurate estimate of its thickness. In conjunction with a friend, an experienced microscopical observer, I have, however, tried to form an approximate idea, and with a magnifying power of 56 diameters, it appears about $\frac{1}{32}$ of an inch thick, therefore in reality it may be from $\frac{1}{1800}$ to $\frac{1}{1000}$ of an inch. This is a very rude mode of arriving at its thickness, but it would be quite useless even to guess at the degree of tenuity of the contained crystals or plates. They are embedded at various depths in this thin shaving of mineral, showing no indications of an edge, and are sometimes at such relative distances below each other, that the focus requires to be considerably changed to bring one after the other into full view. Occasionally they are superposed one above another with a space intervening. I have examined some of the individual crystals with powers of 200, 270, 540, 900, and about 1300 diameters, and notwithstanding their extreme tenuity, I have not been able to detect the least appearance of structure, or breach of continuity in the uniformly flat orange-yellow surface which they present to the eye by transmitted light. Where a crystal happens to be imperfect, its broken edge examined with a high power, resembles torn paper, but has no indication of geometrical symmetry.

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* I have also considered those of Professor Tyndall, just published in the 'Proceedings of the Royal Society,' and fully reported in our Chronicle of Physics; but although they are very interesting, I do not at present see anything in them to throw fresh light on our inquiry.

† My correspondent, Mr. T. Rudler, of the Museum of Practical Geology, gives me the following account of the "Sonnenstein."

"The mineral called by the Germans '*Sonnenstein*,' by the French '*Pierre de Soleil*,' and by the English '*Sun-stone*,' is a variety of Oligoclase-felspar, originally discovered at Archangel, but now found chiefly in Norway. It exhibits a beautiful spangled appearance, somewhat resembling that of Aventurine, and hence it has been called Aventurine-felspar. This appearance is apparently due to the reflection of light from the walls of minute fissures traversing the stone, and also to the presence of small six-sided plates which are usually disseminated through the mineral. What they really are, is difficult to say. Scheerer regarded them as crystals of specular Iron Ore (anhydrous Peroxide of Iron), and Oschatz confirmed this observation, but Kenngott will have it that they are magnetic pyrites (Pyrrhotine). Some, I believe, regard them as titaniferous iron ore, whilst others refer them to the species Göthite. Formerly they were thought to be little scales of Mica.

"I ought, perhaps, to say there is some little confusion in the use of the word 'Sun-stone,' as a few writers have applied it to an opalescent potash-felspar, or Adularia. The beautiful colours exhibited under the microscope by the embedded crystals are due, I should think, rather to their extreme thinness than to any colour inherent in the crystals."

To this account of Mr. Rudler, I would add that from the analogy between them and the iridescent butterfly scales (Figs. 2 and 2a in my Plate) which are red by transmitted, and blue by incident light, I have no doubt that their brilliant colours are due to reflexion from their surface. In my specimen there are scales which are opaque by transmitted light and which more nearly resemble a crumpled fragment of metallic tinsel than a flat geometrical crystal; indeed the crystals are very irregular and not often six-sided.

As already stated, these crystals, which by transmitted light are a uniform orange, by incident light *reflect* all the colours of the spectrum, each crystal reflecting usually one colour, but often the same is variously tinted. In Fig. 7 I have attempted to represent a few of them, but no idea can be formed of their brilliancy unless they are seen under a good bright light in nature. Sometimes (as in the three upper crystals in the figure) the same crystal reflects a metallic lustre in one position, and exhibits the orange transparency in another. Sometimes again, a sharp line divides a crystal in two, and if it be moved round, each division will, by turns, present the transparent orange and the reflected light. This is doubtless owing to the light being reflected from some neighbouring crystal or from one of the fissures of the felspar, and passing upwards through the whole or part of the crystal, as in the case where transmitted light is used.

The matrix of felspar partially depolarizes polarized light, but the latter has not the least effect upon the imbedded crystals.

Before considering the bearing of these phenomena upon our inquiry, let us briefly refer to another, in which the experimenter calls into action the force of which he at the same time observes the effect upon matter. It will be found described in Professor Tyndall's 'Radiation,'* already quoted, and is one for which we are indebted to the researches of Dr. Draper. By means of a current of electricity, a platinum wire is gradually raised to a state of incandescence, and after the luminous rays emitted by the wire have passed through a prism, the prismatic colours appear one by one as the light becomes more intense, beginning at the red, and ending at the violet end of the spectrum, until from a white light in the wire the whole of the spectrum is obtained upon the screen.

And now, before we endeavour to glean from these phenomena what information we are able concerning the action of light, let us try to define what "light" means. Of course, according to the "ethereal hypothesis," it is the vibrations of the atoms of the hypothetical "ether;" but if we adopted this definition we should be admitting the hypothesis of which we desire to test the accuracy, and should be reasoning from the unknown to the known: this we must of course avoid.

All observers will agree in regarding light as a *force* operating upon and causing a motion of matter. It proceeds in a right line and passes freely, and probably unchanged except in degree of intensity, through air, through what *we call* a vacuum, and, when it falls upon them at certain angles, through other forms of matter which are known as transparent; but it is also a force, capable when it reaches some forms of matter, (by what means we cannot say), of resolving itself into three or more distinct modes of action, differing in their nature and operation. Sometimes one of these modifications of the force is incapable of producing any perceptible effect upon a particular form of matter, and then it reflects back upon and through the same unknown medium until it reaches the retina, where it produces the effect known as *colour*. At other times some portion of the force is inoperative when it reaches the surface of the material object, and then its reaction or reflexion causes a combination of colours. In other cases again, chiefly when the force reaches certain forms of matter at a particular angle, no portion of the force is able to affect it, and then we have what is called the reflexion of ordinary light, but there are cases where the whole force is capable of acting upon and through the same form of matter, but whereas it entered it as one whole force, it issues from it as three or more distinct forces or phases of force, and those forces, when they again reach certain forms of matter, reflect upon the retina as a complete "spectrum."

Of all these effects of the force "light" we have had examples in the phenomena already referred to, and in some of them, as for example in the sunstone, we had, in the same object, illustrations of nearly all the modifications to which the original force is subject, and of its resolution as above stated. And now let us inquire whether and in what manner light differs in its operation from the other known forces, or "modes of motion." First, as regards its penetrability. If we do *not* assume that the medium which serves as its vehicle until it reaches a solid object enters into the constitution of that object, but that it is arrested at its surface, then we shall find that the *impact* produces the same effects in the case of light as in other forces, and, moreover, we shall avoid a grave difficulty attending the assumption that the hypothetical "ether" serves as the vehicle of light in and through the solid body, namely, that porous substances through which the "ether" should pass most freely are opaque, whilst dense forms of the identical substance are transparent.

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* 'Radiation,' pp. 2, 3.

If we place a number of billiard-balls in a row thus (Fig. 1),

FIG. 1.

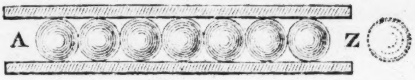


FIG. 2.

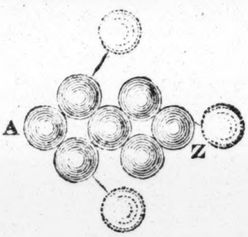
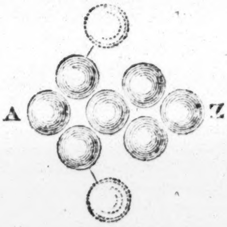


FIG. 3.



and drive a ball or other object against the terminal ball A, the force traverses the whole closely-packed series instantaneously, and the ball Z starts forward at once;* but if the balls are disposed as at Fig. 2, and A be struck with the same force, Z will only move slightly forward, and not so instantaneously as before; and if they be disposed as at Fig. 3, not touching each other, then if A be struck, Z will not move at all, but some of the intervening balls will fly off laterally at different angles. Now the first position (Fig. 1) may be assumed to be that of the particles of matter in a *dense*, and the other two in porous bodies, and if we regard light as a "mode of motion," there is nothing abnormal in its passing more rapidly through, or, to speak correctly, in its traversing the particles of a dense than a porous body, merely on account of the density, and provided the particles be conveniently disposed. Again, air is the medium of *sound*, as ether is supposed to be that of light; but when sound, or rather the agitated air,† impinges upon the sonorous object, the air does not enter into the object, but the force is transferred to the material particles of the object itself. Blow into the air and you have no sound (except that caused by the compression of the air between the lips). The air is transparent or nearly so, to sound. Blow upon a tumbler, and you have a "note." There is a reflection or reaction of part of the force upon the air, and an absorption of the other into the sonorous substance; and, precisely as in the case of light, the effect produced is varied according to the nature of the object upon which the force impinges. Professor Tyndall has shown the close analogies between sound and light in his beautiful work on the former force;* but I cannot help thinking that if he had considered the nature of the "chromatic" scale in both cases, conjointly with the other resemblances between the two forces, his views regarding a hypothetical ether *circulating within bodies*, would have become modified. He attributes the velocity of sound in its passage through substances, to a direct action upon the matter itself; but why not suppose some attenuated gas to be the medium, as sonorous "ether?" Such a supposition is at once negatived by the fact that whilst the velocity of sound through the rarest of gases is only 4164 feet in a second,† it traverses steel wire at the rate of 16,023 feet per second. The density of a substance does not therefore necessarily impede the passage of *sound* (any more than that of mechanical *motion*), and when the field of operation of the force is changed, and it leaves a rarer form of matter to act upon a denser one, its effect in the new direction is intensified and its result upon the senses changed.

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* Professor Tyndall employs this illustration to exhibit the effect of sound.

† Perhaps it would be more correct to say that sound is the vibration of the sensible, as heat and light are the vibrations of the insensible parts of an object. The latter definition is Locke's.

So far, then, as the analogies between light and sound, as well as the mere density of bodies, are concerned, we are at least as correct in leaving the "ether" (whatever that may be) at the outside, as in admitting its presence within solid bodies; and now let us inquire how various substances behave under the influence of light as compared with other forces, which are supposed by the etherealists to have the ether for their vehicle *everywhere*, within as well as without solid objects.

The following are the conducting or transmitting powers of certain well-known types of matter:—

	Heat.	Light.	Electricity.
Metals	good	bad	good.
Charcoal	fair	bad	good.
Ice	bad	good	fair.
Porcelain	bad	fair	bad.
Glass	bad	good	bad.
Rock Salt ..	bad	good	bad.

Now, when we consider these phenomena along with those referred to in our illustrations, we must be struck with the insufficiency of the "ethereal" hypothesis to afford an explanation of them. On the contrary, I fear the remark of Dr. Frankland,* which I apprehend he meant to be applied to this hypothesis, holds good, that "it hinders rather than expedites the advance of the experimenter." Suppose we were to assume that the "ether suffers no rupture of continuity" at the surface of glass, for instance;† how is it that the force, "light," acting upon that "ether," passes through the glass freely, whilst one of its resolved forces or phases, heat, notwithstanding that it operates solely upon the same hypothetical medium, is unable to pass? It cannot be merely because "light" proper acts upon the ether with greater intensity, causing it to vibrate more rapidly than heat; for, according to Professor Tyndall, that would result in the mere phenomena of light and darkness. "Darkness," he says, "may be defined as ether at rest; light as ether in motion:"‡ and although the same author says the ether never is at rest, and that when light-waves are not passing through it, heat-waves are; yet I do not see how the two forces can be severed, and more especially how one can be reflected (or, more strictly speaking, can reflect) back, whilst the other proceeds onwards, as we found it to do in our insect scales and in the other cases described, unless the medium which yields to one phase of the force, and resists the passage of the other, is different from that which serves as the vehicle of the reflected force, or is invested with the attributes of various kinds of gross matter; and, indeed, it appears to me that there must be either a distinct form of "ether" for each force, or *one phase of the force must act directly* upon the constituent particles of the object which is transparent to it, and the other react upon the medium which served as its vehicle until it reached the surface of the solid object. Nor can we suppose "ether" to be invested with attributes which cause it to change the character of the force with the direction of its passage through it; for although the *velocity* of heat travelling through certain crystals is greater in one direction than in another,§ and along the fibre of wood greater than across it;‖ yet it always remains "heat," a force which is supposed by the etherealists to consist, like light, of the "vibration of ether" *everywhere*, so in whichever way we try to use the "ether," we always find that it is the particles of matter which, after all, modify the force.

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* 'On Sound,' p. 44. Longmans.

† Ibid., p. 37.

There is another circumstance which I should like to submit for the consideration of those who are desirous of forming accurate conclusions on this interesting subject. There is no reason why the form of matter which is believed to serve as the vehicle of light should be so extremely attenuated as the "ether" is supposed to be, except the necessity which seems to exist in the minds of the etherealists of its permeating all other matter; but when we look at the known attenuated forms of matter, we find that even the most highly rarefied are unable to penetrate certain dense substances, and pass through porous ones slowly. Professor Faraday found that the materials upon which he operated were pervious to the passage of gases and vapours, but what must be the nature of that "ether," through which the light waves are supposed to speed, undergoing transformations in their passage, and which must be continuous in its presence through the various dense substances composing "Sonnenstein." First, it must pass through a thickness of glass and through felspar, in both of which it must serve as the vehicle of colourless light; then it must be agitated within an embedded crystal, or if there be two superposed, then through both and the intervening felspar, and in all three it must serve as the medium for the force which subsequently becomes apparent to the sense as orange light; then another layer of felspar intervenes; next, flint and crown glass; and then it passes through air, a form of matter in which the hypothetical ether may be supposed to agitate freely. But here its course is not ended; lens after lens of the microscope, each with its particles closely packed, and humour after humour of the eye must all be filled with this attenuated "ether," and must afford space for and be accommodated to instantaneous changes in its varied vibrations.

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* 'Proceedings of Royal Institution,' June 12, 1868.

† I have taken glass as a familiar example, but rock-salt is a better one.

‡ 'Radiation,' p. 9.

§ 'Heat as a Mode of Motion,' p. 221.

‖ Ibid., p. 223.

I have no wish to dogmatize upon this difficult theme, my purpose being, as stated at the outset, to present a few phenomena for the consideration of the reader, and to suggest such inquiries as seem to me calculated to throw light on the subject. From the foregoing remarks, however, it will be clear that I lean to Grove's view of the purely material character of the substances which serve as the vehicles of light, and that, notwithstanding the need which appears to exist for some special medium, either elementary or compound, to provide for its passage across a "vacuum," yet I cannot admit either the possibility or necessity for a *specific* "ether" which permeates all matter. For although the chain of hypotheses which must be employed to support the one hypothesis of a homogeneous specific "ether," filling all space and "fitted mechanically for the transmission of the vibrations of light and heat,"* and permeating all kinds of gross matter, may seem necessary and justifiable in the minds of those who are more accustomed than I am to consider these phenomena, yet it seems to me that before the hypothesis becomes a theory it will be necessary to invest the "ether" with the properties of a variety of forms of known matter, in addition to some abnormal attributes which it is already supposed to possess, and such a proceeding appears less philosophical than to seek in the phenomena connected with known forms of matter, a revelation of the nature and *modus operandi* of "light" and its constituent forces; or failing that, to wait patiently for the discovery of new material conditions that may render the problem less difficult of solution.*

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* Tyndall's 'Radiation,' p. 8.

DESCRIPTION OF THE PLATE.

FIG. 1.—Battledore scale of *Lycæna Adonis* (Clifton Blue Butterfly), viewed by transmitted light, magnified 250 diameters.
,, 1*a*.—The same, viewed by incident light, magnified 250 diameters.
,, 2.—Another scale of *Lycæna Adonis*, viewed by transmitted light, magnified 150 diameters.
,, 2*a*.—The same, viewed by incident light, magnified 150 diameters. Colour probably due to structural arrangement of particles.
,, 3.—Another scale of the same, viewed by transmitted light, magnified 150 diameters.
,, 3*a*.—Scale of the same, viewed by incident light, magnified 150 diameters. Colour due to pigment.
FIG. 4.—Scale of *Vanessa Atalanta* (The Admiral), magnified 150 diameters. Colour due to pigment.
,, 5.—Scale of *Lycæna Alexis* (the Common Blue), magnified 150 diameters.
,, 6.—"Sonnenstein," by transmitted light, magnified 5 diameters.
,, 6*a*.—The same, by incident light, magnified 5 diameters.
,, 7.—Crystals embedded in "Sonnenstein," viewed by incident light, magnified 75 diameters. (The three upper objects in Fig. 7 are the same crystal in different positions, but always illuminated by incident light.)

II. THE ALKALINE LAKES OF CALIFORNIA.

By J. ARTHUR PHILLIPS.

ALKALINE and thermal springs abound over an area constituting a large proportion of the State of California; whilst in some extensive districts, and particularly in the vicinity of the great Colorado desert, the ground during the dry season is whitened by an incrustation principally consisting of various salts of soda.

In many parts of the country also, although alkaline springs are readily found, potable water is exceedingly scarce, being usually met with but once or twice only in the course of a day's journey.

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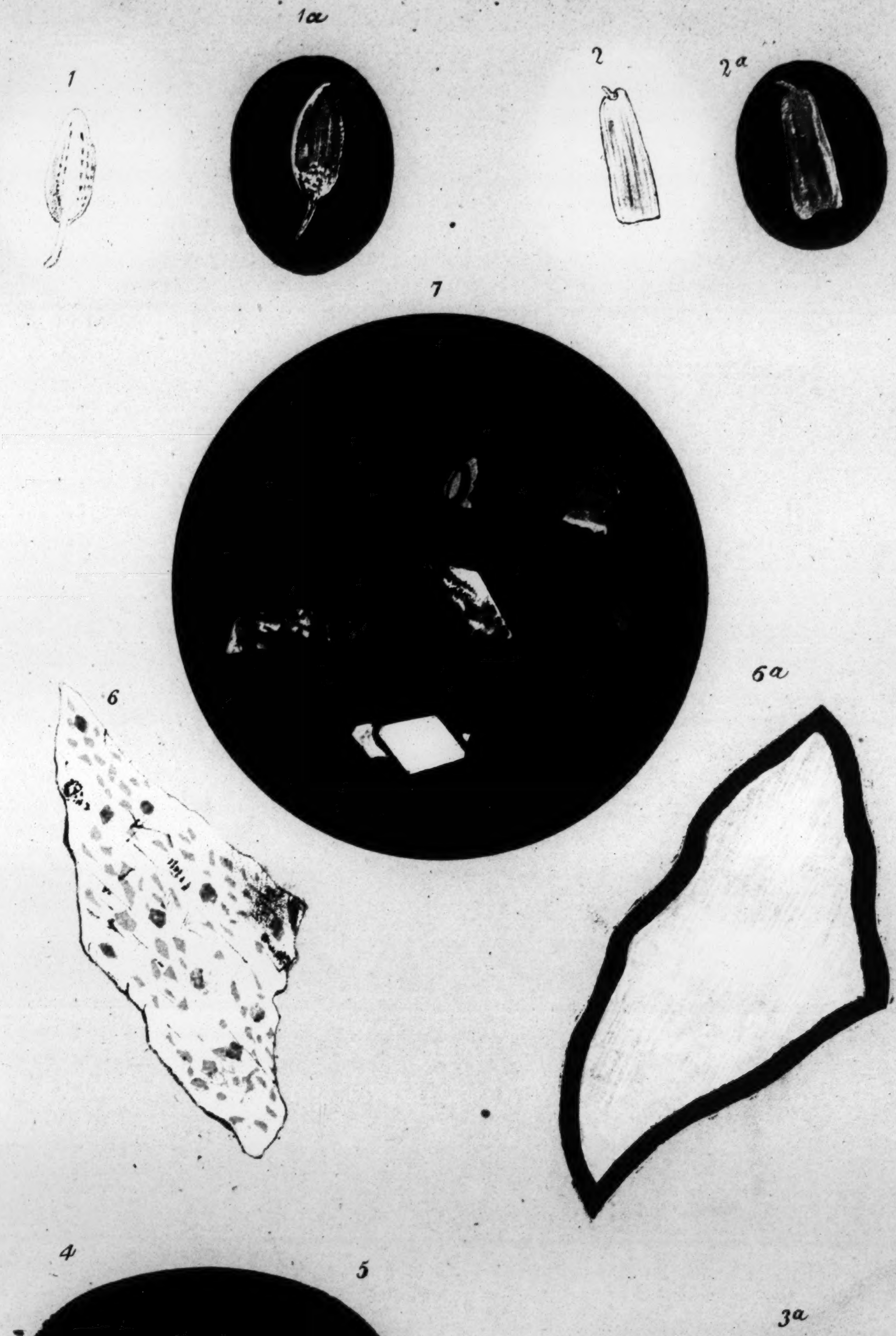
* It is only fair to Professor Tyndall, that after availing myself so largely of his writings, I should mention that his views and speculations on the subject of the "ether," which I need hardly say are well deserving of consideration, will be found in the work just quoted, as well as in his 'Faraday as a Discoverer.'



James Samuelson ad nat. del^t

M. & N. Hanhart, Chromo lith.

MICROSCOPICAL OBJECTS TO ILLUSTRATE THE ARTICLE ON

The most remarkable accumulations of alkaline waters are, however, those of Mono Lake and Owen's Lake; and of these, together with the celebrated Borax Lake, I propose giving a short description.

Mono Lake.—Mono Lake is about fourteen miles long from east to west, and, in its broadest portion, nine miles wide from north to south; it was, however, formerly much larger than it now is, its ancient shore-lines being very conspicuously indicated by a succession of parallel terraces.

On its south-eastern side a ravine has been eroded through the sandy desert which surrounds it, to a depth of from sixty to a hundred feet; and in this cañon five well-defined terraces may be distinctly seen. The level of the lake was once certainly at least 600 feet higher than it now is; and it is not improbable that it then communicated with the valleys both of the Carson and Humboldt, thus forming a most important feature in the ancient geography of the country.

The waters of this lake, which have a high specific gravity, are intensely alkaline and saline, removing grease readily, and being far more detergent in their properties than ordinary soap-suds.

They contain, in addition to common salt, large quantities of carbonate and sulphate of soda, and apparently also a certain proportion of lime, since large quantities of calcareous tufa have been deposited along the lake-shore, and on the terraces far above the present level of its waters. Near its northern shore are numerous springs holding much lime in solution; these have caused the formation of extensive deposits of tufa, some of which rise above the surface of the lake, resembling gigantic fungi of from six to ten feet in height.

In Mono Lake there are several islands, two of which are of considerable size,—the larger being two-and-half miles in length, whilst the smaller is about half-a-mile long. To the north of this lies a group of volcanic islets of inconsiderable dimensions. On the south-eastern corner of the larger island are numerous hot springs accompanied by jets of steam, covering some thirty acres of land, and extending into the lake itself, thus perceptibly raising its temperature for a considerable distance.

The steam and heated gases thus escaping at the same time from hundreds of fumeroles, are often attended with considerable noise, and deposit around the orifices of many of the apertures a red incrustation, probably of chloride of iron: there is, however, no smell of sulphur, nor any deposit of that substance. On the north side of the island are two well-defined craters in the midst of hard basaltic rock, but both are now filled with water.

The smaller island is entirely composed of hard, dark basalt; and has at its western extremity a somewhat elevated volcanic cone of black basalt capped by cinders.

Myriads of aquatic birds resort during the breeding season to this lake; but its waters are, with the exception of the larva of a fly, destitute of life. These larvæ, which are small white worms, occur in such immense quantities, that they are collected by the Indians, under the name of "Koo-chah-bee," as an important article of food. For this purpose they are first dried in the sun; the hard cuticle is then crushed by rubbing between the hands, and afterwards separated by winnowing in large shallow baskets. Before being eaten, the prepared grubs are kneaded into a kind of dough, and baked in the embers.

Stretching south from Mono Lake is a chain of extinct volcanoes: obsidian and pumice are abundant throughout the whole region, the soil being so intensely dry and pulverulent, that the traveller sinks over his ankles at every step, and experiences no small difficulty in obtaining even a scanty supply of fresh water.

Owen's Lake.—This lake is situated about a hundred miles to the south-east of the foregoing, in lat. 36° 20′ S., long. 118° W. from Greenwich, and is twenty-two miles in length, and about eight in width. Owen's River rises in the Sierra Nevada, not far from the head of the San Joaquin, and near the southern extremity of the valley flows into Owen's Lake, which has no visible outlet, and whose shores are thickly coated by an alkaline incrustation. No fish of any description are found in its waters, but they produce large quantities of *koo-chah-bee*, which is plentifully collected by the various tribes of Indians inhabiting its shores, and dried for winter consumption.

The water of this lake has a specific gravity of 1·076, and contains 7128·24 grs. of solid matter to the imperial gallon; of this, 2942 grs. are chloride of sodium, 956 grs. sulphate of soda, and 2914 grs. carbonate of soda. The remainder consists of sulphate and phosphate of potash, silica, and traces of organic matter. Iodine is also present in very minute proportions.

The incrustations which at certain seasons of the year are deposited on its shores to the extent of many hundreds of tons, consist of a yellowish-white efflorescence. A specimen of this substance subjected to analysis afforded the following results:—

Chloride of Sodium	2·14
Sulphate of Soda	3·10
Carbonate "	46·10
Silica	0·22
Potash	traces
Water with traces of organic matter ..	48·44
	100·00

The carbonic acid and soda in this case exist in such proportions as to form a monocarbonate of that base; but fragments collected from various other localities along the lake-shore showed a distinct excess of carbonic acid.

Twenty miles south of Owen's Lake is Little Lake, a pond evidently occupying the crater of an extinct volcano, and in the vicinity of which are some remarkable boiling springs. The country between Little Lake and Owen's Lake is a barren sandy plain, in which the only vegetation consists of a few cactuses, together with some stunted wild-sage bushes and grease-wood; whilst the surface of the ground is everywhere thickly strewn with fragments of obsidian, pumice, and tufa. These, with numerous extinct craters seen in the distance, sufficiently indicate the volcanic nature of the whole region.

Borax Lake.—This sheet of water, the Lake "Kaysa" of the Indians, is situated in Lake County, 110 miles from San Francisco, and lies a little east of Clear Lake, about half-way between Cache Creek and Hawkin's Arm.

This lake, which is separated from Clear Lake by a low range of hills belonging to the cretaceous period, has, under ordinary circumstances, a length of about a mile and an average width of half-a-mile. Its extent, however, varies considerably at different periods of the year, since its waters cover a larger area in spring than during the autumnal months. No stream of any kind flows into the basin, which derives its supply of water from the drainage of the surrounding hills, as well as, in all probability, from subterraneous springs discharging themselves into the bottom of the lake. In ordinary seasons the depth thus varies from 5 feet in the month of April, to 2 feet at the end of October.

Borax occurs in the form of crystals of various dimensions embedded in the mud of the bottom, which is of an exceedingly unctuous character, and is found to be most productive to a depth of about 3½ feet, although a bore-hole, which was sunk near its centre to a depth of 60 feet, afforded a certain proportion of that salt throughout its whole extent.

The crystals thus occurring are most abundant near the centre of the lake, and this rich portion extends over an area equivalent to about one-third of its surface. They are, however, also met with in smaller quantities in the muddy deposit of the other portions of the basin, some of them being, in the richest part before alluded to, over a pound in weight. The largest crystals are generally enclosed in a stiff blue clay, at a depth of between 3 and 4 feet, and a short distance above them is a nearly pure stratum of smaller ones, some 2½ inches in thickness, in addition to which crystals of various sizes are disseminated throughout the muddy deposit of which the bottom consists.

Besides the borax thus found in a crystalline form, the mud is itself highly charged with that salt, and according to Oxland, when dried, affords (including the enclosed crystals) 17·73 per cent. Another sample, analyzed by Mr. Moore of San Francisco, afforded him 18·86 per cent. of crystallized borax.

In addition to this the deposit at the bottom of the other portions of the basin, although less productive, still contains a large amount of borax, and it has been ascertained by sinking numerous pits on the lake shore, that clay containing a certain proportion of this salt exists in all the low ground around it.

The borax at present manufactured is exclusively prepared from the native crystals of crude salt, whilst the mud in which they are found is returned to the lake, after the mechanical separation of the crystals by washing. The extraction of mud from the bottom is effected by the aid of sheet-iron coffer-dams, and dredging-machines worked by manual power, the whole of the labourers being Chinese. Until 1866 the only apparatus employed consisted of a raft covered by a shingled roof, with an aperture in its centre, about 15 feet square, and above which were hung, by suitable tackle, four iron coffer-dams each 6 feet square and 9 feet in depth. This raft or barge was moved in parallel lines across the surface of the lake, and at each station the four dams were sunk simultaneously by their own weight into the mud forming the bottom. When they had thus become well embedded, the water was baled out, and the mud removed in buckets to large rectangular washing-vats, into which a continuous stream of water was introduced from the lake by means of Chinese pumps, the contents of the cisterns being at the same time constantly agitated by rakes.

At the present time dredging-machines are employed for bringing up the mud and crystals from the bottom of the lake, and these are introduced into cisterns and washed as above described. In this way the turbid water continually flows off, and a certain amount of crystallized borax is finally collected in the bottom of each tank. This is subsequently re-crystallized, but from the density acquired by the washing water, of which some hundred thousand gallons are daily employed, it is evident that less than one-half the borax existing in the form of crystals is thus obtained, whilst that present in the mud itself is again returned to the lake.

In 1866, when I visited this locality, the crystals of crude borax daily obtained amounted to about 3000 lbs., and after being carefully washed, they were dissolved in boiling water and re-crystallized in large lead-lined vessels, from which the crystallized borax was removed into boxes each containing a hundred-weight.

The amount of refined salt daily obtained varied from 2500 to 2600 lbs., which was produced, as nearly as I could calculate, at a cost of about 18*l.* per ton.

It is evident from the foregoing description that the system of working employed is exceedingly crude, and by no means calculated for obtaining the best results, and that in order to do so, it would be necessary to adopt some efficient process for the lixiviation of the mud after its removal from the bottom of the lake, and the recrystallization of the borax thus obtained.

The total extent of the muddy deposit considerably exceeds 300 acres, and if we assume that of this area 100 acres, or that portion only now worked for borax crystals, would be sufficiently rich to pay the expenses of treatment by the process at present employed, we shall arrive at the following figures:—

One hundred acres are equivalent to 484,000 square yards, and if the mud were worked only to a depth of 3½ feet, this would represent about 565,000 cubic yards, or, allowing a cubic yard to weigh a ton, which is a very low estimate, the total weight of 100 acres of mud, in its wet state, will be approximately 565,000 tons. If the mud, as extracted from the lake, be now assumed to contain sixty per cent. of water, there will remain 226,000 tons of dry mud, containing, according to the mean of the analyses of Messrs. Oxland and Moore, 18·29 per cent. of borax, but if in practice only twelve per cent. of borax were obtained, this area alone would afford 27,120 tons of crystallized salt.

According to Mr. S. M'Adam, of Edinburgh, to whom a specimen was forwarded for analysis, the crude borax from Borax Lake has the following composition:—

Biborate of Soda, dry	51·85
Water of Crystallization	45·44
Insoluble matter	1·42
Sulphate of Soda, dry	0·06
Chloride of Sodium, dry	0·08
Phosphate of Soda, dry	1·15
	100·00

Mr. Moore, of San Francisco, gives the following as the composition of the water of Borax Lake, which has a mean specific gravity of 1·0274:—

In an Imperial Gallon.

Chloride of Sodium	1198·66
,, Potassium	9·92
Iodide of Magnesium	·22
Bromide ,, ...	trace
Bicarbonate of Magnesia	,,
,, Soda	188·28
,, Ammonia	trace
Carbonate of Soda	578·65
Biborate ,, ...	281·48
Phosphate of alumina	3·52
Sulphate of Lime	trace
Silicic acid	2·37
Matters volatile at a red heat	238·66
	2501·76

In the foregoing analysis all the salts have been calculated as being anhydrous; but crystallized borax contains about 47 per cent. of water, and hence the 281·48 grains found will correspond to 535·08 grains of crystallized salt. Besides the amount of biborate of soda contained in the mud of the lake, its waters are therefore capable of affording at least 6000 additional tons.

The borax, being the least soluble salt present in any considerable quantity, has evidently been deposited in the form of crystals in the mud at the bottom; and that the process is still rapidly going on is shown by the coating of crystals formed upon sticks or other substances immersed for a short time in the waters of the lake. A consideration of the phenomena attending the production of borax further leads to the belief that its formation is effected by the decomposition of carbonate of soda by boracic acid emitted from sources beneath its bed, and large quantities of carbonic acid constantly escape from the surface of the water. Should this be the case, it is more than probable that any moderate extraction of borax will be fully compensated for by the formation of that salt constantly taking place.

The waters of another lake situated in a little valley a few miles north-east of Clear Lake, and surrounded by a thick forest of oak and pine, are also known to contain borax. The bottom of this lake, which covers an area of about twenty acres, consists of a clay similar to that found in the larger one; but although it contains large quantities of borax in solution, no crystals of that salt have as yet been found in the mud. In addition to the localities already mentioned, there are numerous springs in the vicinity of the lakes, the waters of which are more or less impregnated with borax.

To the north-east of Borax Lake, and about a mile from it on the borders of Clear Lake, is a large deposit of sulphur where solfatara action is still apparent. The volcanic rocks have here been extensively fissured and decomposed, and from the various orifices steam and sulphurous vapours are constantly issuing. The amount of sulphur which has been deposited in this place is very large, covering an area of several acres, but the depth to which it may extend can only be ascertained by the further development of the excavations now in progress.

From six to eight tons of this sulphur are refined daily by distillation in large iron retorts, after which it is used for the manufacture of sulphuric acid, and in gunpowder, match, and other factories. The most interesting fact in connection with this deposit is the association of cinnabar with the sulphur sometimes distinctly separated from it, in quartz, evidently of recent origin and deposited from solution, but more frequently thoroughly intermixed with the mass.

Another large deposit of sulphur, about two miles distant, occurs in what is known as Chalk Mountain, so called on account of its peculiar white appearance, caused by the decomposition of the volcanic rock; and still another at Sulphur Springs, farther east on the road to Colusa: but in neither of these localities is the sulphur discoloured by the presence of cinnabar. The rocks at Chalk Mountain are extensively fissured and much decomposed by the action of steam and acid vapours, and springs yielding water highly charged with carbonic acid are numerous throughout the district. In fact, volcanic materials and hot springs occur in a line from Clear Lake eastward toward the Sacramento valley, and, as Professor Whitney remarks, there is evidence of a transverse fissure extending from the Geysers across the volcanic belt, of which Mount St. Helena is the culminating point, to the Sacramento valley.

III. EXPERIMENTAL RESEARCHES ON THE MECHANICAL PROPERTIES OF STEEL.

By Wm. Fairbairn, LL.D., F.R.S., &c.

The present may be justly considered the age of iron, as in every branch of industry where force, form, and motion are required, iron enters largely into construction, and its powers of application have supplanted almost every other material. It presents wonderful facilities in its adaptation to every description of art, whether of the useful or decorative style; and its improved tenacity, elasticity, and ductility have enlarged its field of usefulness in the construction of buildings, ships, steam-engines, bridges, and machinery of all sorts where strength combined with lightness is required. To this powerful and valuable material we are indebted for railways, locomotives, and rolling stock; and there is no branch of manufacture in which it does not form a whole or a prominent part. Possessed of such a material in its cheapest and best forms, we should be deficient in duty if we left it in the rude state in which it was found in the days of Cort, and his immediate successors. That great improvements have been effected of late years does not admit of doubt, and there is probably no material that has undergone greater changes in its manufacture than iron; and judging from the attempts that are now making, and have been made, to improve its quality and to enlarge its sphere of application, we may reasonably conclude that it is destined to attain still greater advances in its chemical and mechanical properties. The earliest improvements in the process of the manufacture of iron may be attributed to Cort, who introduced the process of boiling and puddling in the reverberatory furnace, and those of more recent date to Bessemer, who first used a separate vessel for the reduction of the metals, and thus effected more important changes in the manufacture of iron and steel than had been introduced at any former period in metallurgic history. To the latter system we owe most of the improvements that have taken place; for by the comparatively new and interesting process of burning out the carbon in a separate vessel, almost every description of steel and refined iron may be produced. The same results may be obtained by the puddling-furnace, but not to the same extent, since the artificial blast of the Bessemer principle acts with much greater force in depriving the metal of its carbon, and in reducing it to the state of refined iron. By this new process increased facilities are afforded for attaining new combinations, by the introduction of measured quantities of carbon into the converting vessel, and this may be so regulated as to form steel or iron of the homogeneous state, of any known quality.

The production of iron and steel in the homogeneous state is one of the most important improvements that have taken place since the process of rolling direct from the reverberatory furnace. The former process was first to melt the iron as it came from the smelting-furnace in the shape of pigs, to puddle it or to stir it about until the mass took the form of a ball deprived of its carbon; it was then placed under the hammer, and formed into slabs or ingots. The next process was to roll it into bars, which being cut into short pieces, were again heated and rolled either into plates or bars as required.

Now the great defect of this process was the unsound state of the iron, as the least rust or scoriæ on the surface of the piled bars prevented the welding or fusion of the metals, and hence followed what are called blistered plates, or laminated bars of unsound construction.

The new process it will be observed obviates all these difficulties, as in the Bessemer process the melted iron is deprived of its carbon by the action of an artificial blast—the same as formerly prevailed on the hearth of the refinery—and thence it is cast into ingots of the weight required, either for the hammer or the rolls. From this it will be seen that the risk of piling and welding is entirely dispensed with, and the article produced, whether of iron or steel, is perfect in its homogeneity. It may be of good or inferior quality, hard or soft, but by this process it is free from the risk of being unsound in its homogeneous state.

As regards the steel, of which we have to submit the results, as produced by the principal manufacturers of this country, it will be observed that in making steel from the puddling-furnace, similar combinations may be produced, but with less certainty as regards quality, as everything depends on the skill of the operator in closing the furnace at the precise moment of time, before the mass is deprived of its carbon. This precaution is necessary in order to retain the exact quantity of carbon in the puddled bulb, so as to produce by combination the requisite quality of steel. It will be observed that in the Bessemer process this uncertainty does not exist, as the whole of the carbon is volatilized or burnt out in the first instance; and by pouring into the vessel a certain quantity of crude metal containing carbon, any percentage of that element may be obtained in combination with the iron, possessing qualities best adapted to the varied forms of construction to which it may be applied. Thus the Bessemer process is not only more perfect in itself, but admits of a greater degree of certainty in the results than could possibly be attained by the mere employment of the eyes and hands of the most experienced puddler. Thus it appears that the Bessemer process enables us to manufacture steel with any given proportion of carbon, or other eligible element, and thus to describe the compound metal in terms of its chemical constituents.

Important changes have been made since Mr. Bessemer first announced his new principle of conversion, and the results obtained from various quarters bid fair to establish a new epoch in metallurgic manipulation, by the production of a material of much greater general value than that which was produced by the old process, and in most cases of double the strength of iron.

These improvements are not exclusively confined to the Bessemer process, for a great variety of processes are now in operation producing the same results, and hence we have now in the market homogeneous and every other description of iron, inclusive of steel, of such density, ductility, &c., as to meet all the requirements of the varied forms of construction.

The chemical properties of these different kinds of steel have been satisfactorily established; but we have no reliable knowledge of the mechanical properties of the different descriptions of homogeneous iron and steel that are now being produced. To supply this desideratum, I have endeavoured, by a series of elaborate experiments, to determine the comparative values of the different kinds of steel, as regards their powers of resistance to transverse, tensile, and compressive strain.

These experiments have been instituted not only for those engaged in the constructive arts, but also to enable the engineer to make selections of the ~~material as~~ will best suit his purpose in any work proposed. In order to arrive at correct results I have applied to the first houses for the specimens experimented upon, and judging from the results of these experiments, I venture to hope that new and important data have been obtained, which may safely be relied upon in the selection of the material for the different forms of construction.

For several years past, attempts have been made to substitute steel for iron, on account of its superior tenacity in the construction of ships, boilers, bridges, &c.; and there can be no doubt as to the desirability of employing a material of the same weight and of double the strength, provided it can at all times be relied upon. Some difficulties, however, exist, and until they are removed it would not be safe to make the transfer from iron to steel. These difficulties may be summed up in a few words, *viz.* the want of uniformity in the manufacture, in cases of rolled plates and other articles, which require perfect resemblance in character, and the uncertainty which pervades its production. Time and a close observation of facts in connection with the different processes will, however, surmount these difficulties, and will enable the manufacturer to produce steel in all its varieties with the same certainty as he formerly attained in the manufacture of iron.

In the selection of the different specimens of steel, I have endeavoured to obtain such information about the ores, fuel, and process of manufacture as the parties supplying the specimens were disposed to furnish. To a series of questions, answers were, in most cases, cheerfully given, the particulars of which will be found in the experimental Tables, published in the Transactions of the British Association for 1867.

I have intimated that the specimens have been submitted to transverse, tensile, and compressive strain, and the summaries of results will indicate the uses to which the different specimens may be applied. Table I. gives for each specimen the modulus of elasticity, and the modulus of resistance to impact, together with the deflection for unity of pressure; from these experimental data the engineer and architect may select the steel possessing the actual quality required for any particular structure. This will be found especially requisite in the construction of boilers, ships, bridges, and other structures subjected to severe strains, where safety, strength, and economy should be kept in view.

In the case of transverse strain some difficulties presented themselves in the course of the experiments, arising from the ductile nature of some part of the material, and from its tendency to bend or deflect to a considerable depth without fracture.

But this is always the case with tough bars, whether of iron or steel, and hence the necessity of fixing upon some unit of measure of the deflections, in order to compare the flexibility of the bars with one another, and, from the mean value of this unit of deflection, to obtain a mean value of the modulus of elasticity (E) for the different bars. This unit or measure of flexibility given in the Table, is the mean value of all the deflections corresponding to unity of pressure and section. In order to determine the resistance of the bars to a force analagous to that of impact, *the work* in deflecting each bar up to its limit of elasticity has been calculated. These results differ considerably from each other, showing the different degrees of hardness, ductility, &c., of the material of which the bars are composed. The transverse strength of the different bars up to their limit of elasticity is shown by the amount of the *modulus of strength* or *the unit of strength* calculated for each bar.

Table II., on Tensile Strain, gives the breaking-strain of each bar per square inch of section, and the corresponding elongation of the bar per unit of length, together with the ultimate resistance of each bar to a force analogous to that of impact.

Table III., on Compression, gives the force per square inch of section requisite to crush short columns of the different specimens, with the corresponding compression of the column per unit of length, together with the work expended in producing this compression.

It will be observed from the following Tables that the results of the experiments show that the deflections produced by a transverse strain are in proportion to the pressures within the limits of elasticity.

In Table I., as in the other two on tension and compression, the value of the work done on each specimen has been determined, and the results recorded in the last column indicate the comparative strength of each particular bar; and the mean value of the deflections corresponding to unity of pressure and section will be found in column 3. These may be taken as the measure of flexibility, elasticity, and ductility of the different bars, and the uses to which the material may be applied.

The mean value of E, the modulus of elasticity taken for thirty of the best specimens, is about 31,000,000, which exceeds that of wrought iron by more than the thirtieth part. Steel having a much greater flexibility than malleable iron, accounts for the approximation of their respective values in D_1. This arises from the fact that the bars of the greatest flexibility—other things being the same—have the least value for the modulus of elasticity.

On tensile strain the mean result derived from thirty of the best specimens is 47·7 tons, or nearly 48 tons per square inch; and in this, as in the previous Table, the measure of ductility and strength is given in the last column, which indicates the utility of the material and the purposes for which it may be selected.

Comparing the best quality of steel with the best wrought iron at 24 tons as the breaking-weight per square inch, we find that we have a material of double the strength with the same weight, or what is the same thing, of only half the weight with the same strength, or as 47·7 to 24. In the art of construction these

COMPARISON of STEEL MANUFACTURED after the BESSEMER PROCESS, with that MANUFACTURED by other PROCESSES.

TABLE I.—TRANSVERSE STRAIN on inch-square bars, and 4 ft. 6 in. between the supports.

MANUFACTURER.	Description of Steel.	Mean value, D_1, of the deflection for unity of pressure and section.	Mean value of the modulus of elasticity E.	Mean work of deflection, *u*, for unity of section.	Mean value of C, the unit of working strength.	REMARKS.	
					tons.		lbs.
Messrs. J. Brown & Co.	Bessemer steel	·0012739	30,730,000	52·721	5·918	Mean breaking weight	1000
Messrs. C. Cammell & Co.	,,	·0013518	29,166,000	59·897	5·921	Do.	950
Messrs. H. Bessemer & Co.	,,	·0016684	29,813,000	49·489	5·659	Do.	975
The Hæmatite Steel and Iron Company	,,	·0014590	27,153,000	26·463	3·914	Soft steel.	
Mean	.. ..	·0014382	29,215,000	47·142	5·283		
Messrs. Naylor, Vickers, & Co.	Melted in the crucible	·0013007	30,278,000	65·049	6·548		
Messrs. S. Osborn & Co.	,,	·0014296	27,482,000	52·574	5·622	Mean breaking weight	1250
Messrs. C. Sanderson & Brothers	,,	·0013209	29,973,000	47·411	5·521	Do.	1250
Messrs. T. Turton & Sons	,,	·0013120	30,294,000	52·680	5·886	Do.	1200
The Titanic Steel and Iron Company	Mushet's steel	·0012350	31,901,000	63·542	6·435		
Mean	.. ..	·0013196	30,042,000	56·251	6·002		

TABLE II.—TENSILE STRAIN on bars $\frac{3}{4}$ inch diameter. Elongations taken on 8 in. length.

MANUFACTURER.	Description of Steel.	Specific Gravity.	Mean weight laid on in lbs. producing rupture.	Mean breaking strain per square inch of section.		Mean elongation, per unit of length.	Mean value of *u*, or work producing rupture. By eq. 13.
				lbs.	Tons.		
Messrs. J. Brown & Co.	Bessemer steel	7·7665	33,603	90,379	40·35	·0460	2002
Messrs. Cammell & Co.	.. ..	7·8119	34,085	101,132	45·14	·0595	2714
Messrs. Bessemer & Co.	.. ..	7·7726	38,189	89,955	40·15	·0753	3212
The Hæmatite Steel and Iron Company	.. ..	7·7951	33,321	72,195	32·22	·0942	3351
Mean	.. ..	7·7891	34,299	88,415	39·46	·0682	2819
Messrs. Naylor, Vickers, & Co.	Melted in the crucible	7·8198	39,449	108,099	48·25	·0372	1827
Messrs. S. Osborn & Co.	,,	7·7758	44,131	103,214	46·07	·0341	1842
Messrs. C. Sanderson & Brothers	,,	7·7563	39,592	95,553	42·65	·0229	1566
Messrs. T. Turton & Sons	,,	7·7990	39,295	93,380	41·61	·0165	807
The Titanic Steel and Iron Company	Mushet's steel	7·7883	37,179	93,616	41·79	·0551	2413
Mean	.. ..	7·7878	39,923	98,772	44·07	·0327	1691

COMPARISON OF STEEL — *continued.*

TABLE III.—COMPRESSIVE STRAIN on specimens $\frac{3}{4}$ in. diameter and 1 in. in length.

MANUFACTURER.	Description of Steel.	Mean weight laid on in lbs.	Greatest weight laid on per square inch of section.		Mean compression per unit of length.	Mean value of u, or work expended in crushing the bar.
			lbs.	Tons.		
Messrs. J. Brown & Co.	Bessemer steel	91,840	225,568	100·700	·347	39,101
Messrs. C. Cammell & Co.	,,	91,840	225,568	100·700	·339	38,232
Messrs. H. Bessemer & Co.	,,	91,840	225,568	100·700	·379	42,720
The Hæmatite Steel and Iron Company	,,	91,840	225,568	100·700	·445	50,207
Mean	.. ..	91,840	225,568	100·700	·377	42,981
Messrs. Naylor, Vickers, & Co.	Melted in the crucible	91,840	225,568	100·700	·286	32,300
Messrs. S. Osborn & Co.	,,	91,840	225,568	100·700	·267	30,014
Messrs. C. Sanderson & Brothers	,,	91,840	225,568	100·700	·328	36,906
Messrs. T. Turton & Sons	,,	91,840	225,568	100·700	·398	29,254
The Titanic Steel and Iron Company	Mushet's steel	91,840	225,568	100·700	·315	35,551
Mean	.. ..	91,840	225,568	100·700	·318	32,805

are considerations of great importance; and in every case where steel can be depended upon, it is entitled, on the score of economy and lightness, to the judgment and practical knowledge of the architect and engineer.

In Table III., on compression, each of the specimens were reduced, when cut from the bars previously experimented upon, to small columns of $\frac{3}{4}$ inch diameter and 1 inch in height. They were each loaded with weights equal to 100 tons per square inch, without undergoing any sensible appearance of fracture. On consulting the Table it will be found that with the above weight of 100 tons per square inch they were compressed, on the average, to two-thirds their original length; and from these facts we were enabled to find the value of u, recorded in the last column, as the value of work done by the load which produced the change of form in each of the specimens submitted to pressure. This, it will be observed, was the true test of the powers of resistance of the respective specimens to a compressive strain, and the conditions under which materials of similar properties may be safely applied in constructive art.

On comparing the mean tensile resistance to rupture at 47·7 tons per square inch, it will be seen that the resistance to compression is more than double the resistance to extension, or as 100·7 to 47·7, being in the ratio of near 2 : 1. Hence it follows that the most economic form of a steel bar undergoing a transverse strain would be a bar with double flanges, having the area of the top flange about one-half that of the bottom.

This conclusion is borne out by the results of experiments on transverse strain, where S_1, the strain per square inch of the material at the elastic limit, $= 6\,C = 6 \times 6{\cdot}83$ tons $= 40{\cdot}98$, or 41 tons nearly; but the mean breaking-strain per square inch by extension $= 47{\cdot}7$ tons, clearly indicates that the compressive resistance in the former case was considerably in excess of the tensile resistance.

It is important in every experiment on the strength of materials, which enters so largely into constructive art, that we should be thoroughly acquainted with the properties of the material of which the structure is composed, and that its resistance in all the different forms of strain should be clearly and distinctly ascertained. In the foregoing experiments we have determined the resisting powers of the different specimens to bending, tension, and compression; but we have omitted that of torsion, or twisting, until we have an opportunity of doing so upon the same identical bars. These I hope to accomplish at some future period, and also to give some further results upon an enlarged scale, calculated to confirm what has already been done, and to ascertain some additional facts in regard to the changes now in progress in the manufacture of Iron and Steel.

IV. THE TREASURES OF SILURIA.

Thesaurus Siluricus: The Flora and Fauna of the Silurian Period. With Addenda (from recent acquisitions). By John J. Bigsby, M.D., F.G.S. London: Van Voorst. 1868. 4to, pp. 268.

The "Treasures of Siluria" consist of a vast assemblage of those "Medals of Creation" with which the late Dr. Mantell, years ago, made the intelligent reader familiar. These medals are coins of various denominations, each of which had an unnumbered circulation. But the region over which they severally passed current, and the relative value which belongs to them, are questions which, amongst others, we shall discuss in this article.

At the head of our review we have placed the title of but one book,—not because it gives us every possible information about the "Treasures" whose value we wish to estimate, but because it is a synopsis of everything that has hitherto been published on the subject, and of not a little that is even now in the hands of the printer. Especially let us mention that M. Barrande's 'Système Silurien du Centre de la Bohême—Recherches Paléontologiques,' Professor James Hall's 'Palæontology of New York,' Mr. Davidson's 'British Silurian Brachiopoda,' Mr. Salter's numerous works on Silurian fossils, and the Reports of the Canadian Geological Survey, are the great storehouses from which Dr. Bigsby has collected most of his material, while innumerable memoirs by an army of English, Continental, and American authors have yielded to his search an almost equal number of species.

Dr. Bigsby has, indeed, spent a vast deal of time in groping about amongst the archives of a host of ancient cemeteries of all dates and of all climes. He has found records of the burial of numerous groups of individuals, each group being known by a distinct name. Some of these are represented in countries far apart, and during successive periods of lengthened duration; but the majority of them have remained true to their native country, and have not survived the vicissitudes of climate and conditions to which all regions are more or less subject. In other words, as we shall have occasion to point out again, those individuals and communities which emigrated to distant regions flourished and multiplied, after the manner of more modern emigrants, under the more favourable conditions of their new habitation; while those which remained true to their birthplace succumbed during a struggle for existence with either their own progeny or new colonists, aggravated by a decrease in the means of subsistence and a more rigorous condition of external circumstances.

The 'Thesaurus' contains the names, dates, and habitations of nearly nine thousand species, so far as they are at present known. These species are classified zoologically into their respective orders, the genera of each order and the species of each genus being then given alphabetically. At the end of the list of members of each order is given a "geographical summary," showing at a glance the distribution of the genera and their species over the surface of the globe. Finally, at the end of the book is a very complete list of works on Silurian Palæontology, which will necessarily be of great assistance to future students of the subject.

The untiring and long-sustained industry necessary to the successful compilation of a work of this kind is a quality possessed by comparatively few men of science; and while we rejoice that the Royal Society has recognized and rewarded the perseverance of the author by a grant of 100*l*. in aid of the publication of his book, we sincerely hope that the scientific public will follow so distinguished an example, and will preserve the author from pecuniary loss by purchasing a work of reference unique in its aim, and without which every geological library must be regarded as incomplete.

Preceding the lists of species which form the main body of the work, Dr. Bigsby records a number of "Facts and Observations" as the result of his analysis of them. These general conclusions bear even stronger testimony to the author's industry, and much more powerful witness to the vigour of his intellect, than the lists of species themselves. Indeed, if the 'Thesaurus' had been placed in the hands of a dozen Palæontologists, we doubt whether any one of them would have drawn a more original series of inferences than these same "Facts and Observations;" and we are quite confident that a more suggestive series it would be impossible to bring together.

While it would be both tedious and difficult to scrutinize lists of species, it is infinitely easier to criticize conclusions than it is to arrive at them. The reviewer comes to their examination rather inclined to object to them, while the author, on the other hand, having been for weeks, for months, perhaps for years, accumulating and selecting materials which have suggested to him certain inferences, finds it extremely difficult fully to appreciate such hostile facts as would require very serious modifications of his previous results.

Having thus confessed our bias, we will endeavour to guide our readers fairly through some of the paths trodden by our author, and will commence with that very intricate formation known as the "Primordial Zone."

Although the commencement of what is still included in the "Silurian System" may not be of the greatest importance to the registrar of the births and deaths of Palæozoic fossils, there is no doubt whatever that it possesses the highest interest for the scientific theorist. The "Primordial Zone" must, in fact, be still looked upon as practically the natal epoch of organic life, for the inhabitants of the vastly more ancient Laurentian period are still too little known to enable the Palæontological genealogist to deal with them.

Dr. Bigsby devotes three or four pages to a brief sketch of the salient facts connected with his census of the inhabitants of the Primordial Period, but owing to his apparent desire to extend its limits, he is obliged to commence with the following sentence:—"Waiting for the results of the investigations now taking place in Canada as to the exact relations of the Quebec Group with the Primordial Stage, it will be better not to dwell long on this part of the Silurian Epoch, especially as the present ideas on these relations do not give entire content." He further remarks that "it is indissolubly Silurian by almost every possible tie—by facies, materials, stratigraphy, and organic contents,"—but in this latter conclusion he will not be supported, we think, by our working Welsh geologists.

Dr. Bigsby gives us an imposing summary of the fauna of the Primordial Zone in Europe and America, namely, 375 species in the former, and 597 species in the latter region; but his definition of the formation is so extremely wide that it is difficult, from his figures, to arrive at the real value of the fauna of the period in its more restricted meaning. To prevent any misunderstanding, we give the following comparative statements of what is usually included in this formation, and of what the author includes within its definition:—

BRITAIN.

Bigsby.		Murchison, Belt, Salter, &c.
Lower Llandeilo Skiddaw Slates Arenig Group	Lower Silurian of other authors.	
Stiper Stones Tremadoc Slate	.. ..	Tremadoc Group.
Lingula Flags	.. ..	Ffestiniog Group (Sedgwick). Mænevian Group (Salter).
Harlech Grits	.. ..	Harlech Group.
Llanberis Slates	.. ..	Llanberis Slates.

CANADA AND UNITED STATES.

Bigsby.		Murchison.
Quebec Group	Chazy Limestone (part). Calciferous Sandstone. Point-Lévis Rocks.	
Potsdam Sandstone	.. ..	Lower Calciferous Group. Upper Potsdam Group. Lower Potsdam Group. St. John's Group.

It is thus seen that Dr. Bigsby adds to what is usually termed "Primordial" in Britain, the Lower Llandeilo of Murchison (the Arenig Group and the Skiddaw slates being also of that age), while his classification of the American rocks is still more complicated. According to Sir R. I. Murchison the Lower Calciferous Group is succeeded by (1) the Upper Calciferous Group, and (2) the Quebec Group (including the Lévis, Lauzon, and Sillery rocks), both being regarded by him as of Llandeilo age; and these are again surmounted by the Chazy Limestone, which Sir Roderick refers to the base of the Caradoc formation, but part of which Dr. Bigsby (as we have seen) also includes in the Primordial Zone!

With respect to Bohemia there can be no difficulty, as there, of course, the Primordial Zone is simply the Primordial Zone, the "First Fauna," the C.c.1 of M. Barrande. The question is, What are its equivalents in Britain and America? Or, to bring the matter to a closer issue, Is Dr. Bigsby right in his extension of the definition for Britain and America? We cannot decide this question; but we are obliged by every rule of classification and of argument to assume that the old ideas are correct, until they have been proved to be erroneous. The *onus probandi* lies with Dr. Bigsby, and he has not advanced a single argument in support of his novel classification.

We can allow ourselves to notice but one other conclusion of our author in connection with the Primordial Zone, and that only in relation to the general question of the origin of life. Dr. Bigsby remarks, "The Primordial stage did not start forth, Pallas-like, at once, in full maturity."* This is quite true. In the Llanberis or Bangor slates no fossils have hitherto been discovered, while in the Harlech Grits above, the number of species, and of represented genera, though certainly small, is somewhat uncertain, from the bad state of preservation of many of them; but in the still higher Mænevian group we meet with a tolerably rich and varied fauna. Dr. Bigsby's idea is, that "the quantity, variety, and high rank of its fauna shut us up from any other conclusion than that it is only part, and a rich part, of an already established flora and fauna lying undetected at present."† No doubt this inference is very just, and it is certainly one in which we cordially agree; but we feel some difficulty in reconciling it with our author's dictum of the necessity of "Radiata, Mollusca, Annelida, Articulata, all showing themselves simultaneously, or nearly so."‡

The *first appearance of species*, however, the author discusses very briefly. It is, in truth, a subject on which very few facts can at present be quoted. His proposition that "life started into being, necessarily, in societies both composite and simple," § besides appearing to contradict one of his inferences respecting the Primordial fauna, will probably not meet with general acceptance, although the exact meaning to be ascribed to it seems to us a little doubtful.

Leaving this speculative subject, we will examine some of the many curious facts which illustrate the *duration of species*, which is a matter of very high interest. For instance, M. Barrande has shown ‖ that 32 species of Bohemian Orthoceratites began and ended their existence in one subdivision of the Silurian rocks (E.e.1), while 38 more passed up into the next stage (E.e.2), and there perished. In this latter formation no less than 199 species of the same genus make their appearance, not one of which passes up into the overlying stratum.

In connection with this subject it will be useful to draw attention to Dr. Bigsby's census of the species which are known from only one place,¶ as compared with that of the total number of Silurian species, *viz.*:—

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* P. xx.

† Ibid.

‡ P. xxxvii.

§ Ibid.

‖ See 'Thesaurus,' p. xxxviii.

¶ Pp. vii. and xxxvi.

Groups.	Total Species.	Species of one Locality.
Plantæ	82	47
Amorphozoa	136	92
Foraminifera	25	0
Cœlenterata	507	220
Echinodermata	500	365
Annelida	154	88
Cirripedes	8	6
Trilobita	1611	708
Entomostraca	318	198
Polyzoa	441	265
Brachiopoda	1650	699
Monomyaria	168	87
Dimyaria	541	287
Pteropoda	358	210
Gasteropoda	895	454
Cephalopoda	1454	858
Pisces	37	26
Incertæ sedis	12	10
	8897	4620

The total result is thus seen to be that more than half of the known Silurian species have hitherto been found in only one locality. This fact alone is sufficient to remind us (what Dr. Bigsby quotes) that so thoughtful a naturalist as the late Professor Edward Forbes asserted that a large proportion of all known species of fossils are founded on single specimens.

It is a very remarkable fact that the species which are thus restricted to a small geographical area are also those which attain a small vertical range. Thus, in Bohemia, in two small and adjoining parishes near Prague, we find huddled together no less than 112 species of *Cyrtoceras*, 27 of *Trochoceras*, and 30 of *Orthoceras*, with many other fossils, all of which are confined to one stratum, and none of which have hitherto been found elsewhere.

At the present day large assemblages of species (though their value as such is doubtful), of *one class of animals* exist in certain regions. For instance, the rivers of North America have yielded countless forms of Unionidæ, and those of Brazil (according to Professor Agassiz) no less than 2000 species of fish. These "communities," as Dr. Bigsby calls such populations, had their parallel in Silurian times in Bohemia; for there, in the wonderful deposit E.e.2, which we have already mentioned, no less than 921 species have been discovered in a bed about 150 feet thick, extending over an area not more than 15 miles long by 7 broad. Of this large number, 590 species belong to the order Cephalopoda, and of them no less than 220 species are peculiar to one parish (Lochkov), and 102 to another (Kozorz), while 75 others are common to the two. These 590 species represent only 9 genera, *Orthoceras* including 252 species, *Cyrtoceras* 199, *Gomphoceras*

59, *Trochoceras* 36, *Phragmoceras* 25, and 4 others the remaining 19.

What Dr. Bigsby calls "universality" illustrates the other side of the question in an equally forcible manner. His definition is that "a formation may be considered to be universal when it occupies large and small areas in very many parts of the earth, often remote from, and even antipodal to, each other, when it is always of like stratigraphical relations, is composed of like materials, and contains numerous genera of existences in common, together with some representative, and some identical species." Of course this definition makes the Silurian a universal formation; and if its spirit be truly applicable to a formation, it must be equally so to a genus or a species. Our author has therefore constructed a table, showing that 210 species are common to Europe and America, of which 35 travelled from the Old to the New World (that is, appear in more recent deposits in the latter); 30 from America to Europe; while 145 are what he calls "Isozonals;" that is to say, occur on the same horizon in both hemispheres. At first sight it seems as if Dr. Bigsby were of opinion that the last-named species did not migrate at all, but were sown broadcast over the whole area at the time of their creation. We presume, however, that this is not really his meaning.

Some Silurian species occur almost everywhere where Silurian rocks occur. And it is noteworthy that most of these "universal" species possess also the greatest vertical range, and the greatest variability recognized as such. Take, for instance, the well-known *Calymene Blumenbachii*. This species, though not so variable as some others which might be named, occurs in England in all divisions of the Silurian system, from the Llandeilo to the Wenlock inclusive. And many other instances of a like nature might be quoted. Indeed, our author is well acquainted with them.

As to geographical range, this same *Calymene Blumenbachii*, so well known in the United Kingdom, is found abundantly in the Upper Silurian rocks of Northern Europe, in both the Lower and Upper divisions of the French Silurian strata, and in the Lower, Middle, and Upper divisions in those regions of North America where they respectively occur.

It certainly does surprise us that Dr. Bigsby, in dealing with a topic of such great interest as that of the *duration of species*, should not once allude to the law originally laid down by De Verneuil and D'Archiac, advocated by Forbes, Rogers, and others, and adopted by almost every subsequent writer. This law may be enunciated thus:—Species which are most extended in geographical space are generally those which have the greatest vertical range. It refers specially to organisms of the same rank, and must not therefore be confounded with the law which ascribes the greatest range to the most lowly organized animals.

The general law of the range of species in space and time may therefore be broadly and roughly stated as follows:—long life and great range; short life and restricted range. Now, without at all doubting the fact that the lives of species, like those of individuals, may vary in length to a great extent, we think that naturalists who "count heads" should satisfy themselves whether a species which has spread over three-fourths of the globe, and enjoyed an existence extending through several divisions of the Silurian period, is precisely equivalent in Natural History value to a species of the same genus which, with scores of others, was both created and destroyed within the limits of one minor subdivision of the same period, and which never extended beyond an area of a few square miles. To put this question in a concrete form, let us ask whether *Orthoceras annulatum* is of an equivalent value to, say, *O. intermixtum?* The former is a species which ranges from the Caradoc to the Ludlow rocks inclusive, and from New York, through Northern Europe and Great Britain, to Bohemia, while the latter occurs in only one subdivision (E.e.2) of the Silurian system, and in but one small district in Bohemia.

Taking into consideration the whole of the facts, illustrated as they are by the few which we have described, we feel inclined to believe that whereas some species had strong constitutions, and could sustain changes in conditions and the wear and tear of travel with comparative impunity,—in other words, that they possessed great vitality (Dr. Bigsby calls it viability),—others presented more feeble resistance to such untoward circumstances. These latter either died out altogether or became so far altered as to merit new names at the hands of Palæontologists,—who unfortnately are generally (and frequently of necessity) guided only by the laws of convenience and the rule of thumb.

If we are correct in our estimate of the relative value of species, the very awkward question will arise, What inferences can legitimately be drawn from Dr. Bigsby's synoptical tables? In other words, What is the use of "counting heads?" Echo answers, What? And we believe that we may strengthen our position without violating the truth by ascribing this phrase "counting heads," as well as the first denunciation of the practice, to an eminent geologist who at one time evinced considerable skill in its exercise.

We have now discussed at some length the first appearance and the duration of species, and our space compels us to pass on to a hasty review of the causes which have led to and accompanied their extinction. Dr. Bigsby's statements on this subject are not a little confusing, as some of them include the idea of the action of purely local, and chiefly geographical causes, while others are equally distinct statements of the cosmical (*i.e.* universal) theory of creations and extinctions. For instance, "all beings are subject to external conditions, favourable and unfavourable, which assist in the production of an average longevity." "Extinction of life is commonly slow, continuous, individual, and sometimes is more rapid than replacement from without, or than by acts of creation. Sudden acts of extermination are exceptional, brief in time, and limited in space." Again, the author divides the causes of extinction into two classes, (1) mechanical and (2) physiological. The former includes oscillation of level, climate, &c.; and the latter, such matters as supply of food, overcrowding, epidemics, &c.

With all this most students of the modern school will agree; but we imagine that our readers will be as surprised as ourselves to find amidst so much of the "uniformity" philosophy the following sentence:—"The causes of extinction are in universal operation. They are cosmical. Silurian life was discontinued everywhere at the same time, proximately." Surely, if this statement includes the actual fact, mechanical and physiological causes of extinction may as well be neglected, for their operation must have been too restricted to leave any impress on the geological record.

As a corollary of his cosmical theory, Dr. Bigsby states that "There is no example, as far as I know, of a Silurian *community* rising, by migration or otherwise, into Devonian or Carboniferous strata; but single species do, and somewhat largely, just as we see in every epoch up to the present." Our knowledge is not yet sufficiently advanced to enable us to make many definite statements on this subject; but we may remind Dr. Bigsby that his favourite (and deservedly great) authority, M. Barrande, has shown that the two highest members of his Third Fauna (stages G and H) present less strong connections with the Devonian system than do the still older deposits E and F. Again, the author himself admits that "whole communities have been known to return together to the country they had long abandoned," and he quotes Mr. Godwin-Austen's description of "this kind of repossession in the Palæozoic rocks near Boulogne."

From these considerations the author passes naturally to the question of recurrence, which he defines to be "the reappearance of a plant or animal in a zone of rocks higher than that in which it was first observed. It implies progress upwards, either on the same spot or on another by migration." Used in this sense, it is remarkable how many species may be termed recurrent,—what a large number occur on more than one horizon.

In illustration of the subject, Dr. Bigsby has constructed a table showing a synoptical view of Silurian life in this relation as far as was known in 1865. This table shows us that out of the 5968 Silurian species (exclusive of the Primordial) whose places are well known), 784, or 13 per cent., are recurrents, leaving 5184 faithful to one horizon. But this statement does not describe the scope and value of the table, which may be epitomized as follows:—In the Lower Silurian rocks 354 species occur on two horizons—98 on three, 44 on four, and 5 on five. In the Middle Silurian 95 species occur on two horizons—29 on three, and 3 on four. In the Upper Silurian 138 species occur in two divisions, 15 in three, and 3 in four.

There are many curious facts connected with recurrence, several of which are not yet properly understood. In one region a species may be restricted to one horizon, being there truly typical, while in another region the same species may pass through nearly the whole of the subdivisions of the Silurian series. Speaking generally, recurrence is common in Sweden and Canada, and still more so in Wales. It is rare both in Russia and Bohemia. In the last-named country we have seen that species of short duration and belonging to a small number of genera are extremely abundant. Surely this contrast is another fact in favour of the views we have already advocated.

After reading through the "Facts and Observations," we at first felt somewhat uncertain as to the author's views on the important subject of Contemporaneity of Strata. He does not say much about it; and, with the exception of the first and last sentences which we quote below, his statements do not help us very powerfully to a conclusion.

(1.) "We already have materials from almost all parts of the Silurian scale of rocks to show, with some force (M. Barrande), that life began earlier and more abundantly in the valleys of the St. Lawrence and Mississippi than in Europe." *

(2.) "It would appear that the Silurian system of rocks is universal in extent, and that its component parts were laid down at a proximate time, and in like manner ceased to be laid down, statements approved by M. Barrande." †

(3.) "It is a very striking fact that the great majority of the Silurian fauna made their first appearance on the same horizon—that is, everywhere on, proximately, the same stage or subdivision of the epoch." ‡

(4.) "Silurian life was discontinued everywhere at the same time, proximately." §

(5.) "The Upper Silurian fossils which people the Prague colonies in fauna D.d, except as they come from another area, are not recurrents, are not the posterity of Bohemian mollusks. They are the *precursors* of an identical and larger coming fauna. Signs are not wanting that they come from a country *where the Silurian*

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* P. xi. † P. xxxiii. ‡ P. xxxvii. § P. xl.

epoch was more advanced than in Bohemia;[*] and they become of great value by indicating *local inequality of progress* in the act of deposition during this epoch—suggesting, moreover, that *any of the Silurian stages may be in process of formation about the same time with another in different parts of the world.*"[†]

Now there can be no doubt that our quotations No. 1 and No. 5 show that the author's mind is fairly imbued with the theory of homotaxis in a legitimate and moderate degree; but the only word in the remaining quotations which can possibly receive a "homotaxeous" construction is proximate or proximately; and it is extremely remarkable that this qualification of otherwise rigorous statements occurs in each of the three remaining sentences (Nos. 2, 3, and 4). In a postscript Dr. Bigsby gives a list of "additional subjects," and amongst them we find the following: "The greater or less *synchronism* of strata far apart; measured, where possible. Was America *inhabited* before Europe, &c.?—as seems probable. On the whole, therefore, we must regard our author, veteran though he be, as a geologist of the advanced modern school, and possessing an elasticity of mind not at all common amongst scientific men of his generation.

V. ON NATIONAL INSTITUTIONS FOR PRACTICAL SCIENTIFIC RESEARCH.

By Lieutenant-Colonel Strange, F.R.S., Government Inspector of Scientific Instruments, India Department, and Dr. Mann, F.R.A.S., F.R.G.S., &c., Superintendent of Education, and Special Commissioner of the Government of Natal.[‡]

At the recent Meeting of the British Association for the Advancement of Science, held in the city of Norwich in the month of August last (1868), the Inspector of Scientific Instruments for the India Department brought a subject before the Mathematical and Physical Section of the Congress which had obviously been engaging his attention and thoughts very seriously for some considerable time. In a somewhat lengthened experience in one special department of hard scientific work, Colonel Strange has been led to the important conclusion that unquestionable and vast as has been the service pure and practical science has received from the hands of British contributors, this service has not been commensurate with the proud and deserved position Great Britain has taken up among the advanced nations of the world on other grounds, and that there is one very clear and obvious reason for this undesirable fact which cannot be too soon looked fairly in the face by the best friends and advocates of scientific movement. The Colonel pointed emphatically to the official declaration, that "The objects of the British Association are to give a stronger impulse and more systematic direction to scientific inquiry, and to remove any disadvantages of a public kind which impede its progress," and upon that manifesto based an argument that there is now an imperative call and claim upon the enlightened Association of British Philosophers to take action upon this avowed principle, and use its powerful influence to lead the public mind to a recognition of one great need from which the highest interests of the general community are suffering at the present day. In this appeal Colonel Strange urged the Association to bear well in mind the importance of pressing upon public attention the *comparatively* backward condition of scientific research in the British Islands and dependencies at the present time, and of insisting upon the inexpressible and unassessible value of the mighty engine of human advancement that is thus allowed to remain in relative idleness and disuse, while so many other engines are worked at their utmost speed, and often with a reckless profusion of expenditure, that only makes the contrast so much the more startling and humiliating for a people aiming at a forward position and high excellence. If the views entertained by the originator of this movement be substantiated by facts, there can be no doubt that an association of philosophers which professes to engage itself with "giving a stronger impulse and a more systematic direction to scientific inquiry, and with removing disadvantages that impede its progress," will be bound by its own profession to do all that may be done to indicate how "the intellectual glories and material riches which a bountiful Providence has created for man's use may be best placed, promptly and systematically, at man's disposal."

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[*] These and the following italics are ours.

[†] P. xlvii.

[‡] The authors are the Chairman and Secretary of a Committee appointed by the British Association for the Advancement of Science, at its Session in Norwich, August, 1868, for the investigation of this subject.

The plea which was offered at the Norwich Meeting of the British Association by Colonel Strange was at any rate so far admitted by the court before which he elected to urge the appeal that a committee, comprising the names of Thomson, Tyndall, Frankland, Williamson, Stokes, Fleeming Jenkin, Hirst, Huxley, Balfour Stewart, Stenhouse, Glaisher, and Huggins, besides those of the chairman and secretary, was appointed to consider and report upon the general questions, whether there exist in the United Kingdom of Great Britain and Ireland sufficient provision for the vigorous prosecution of physical research, and whether, if it be held that sufficient provision does not exist, it can be shown what further provision is needed, and what measures can be taken to supply the want.

It will be observed that in this proceeding the action of the

British Association has been purposely and carefully limited to the altogether unexceptionable object of inquiring whether sufficient facilities for the prosecution of scientific research, properly so called, do exist in the kingdom of Great Britain; and of suggesting in what direction it seems most advisable to seek increased facilities, if such are deemed to be required. Whatever scientific men may think of other branches and bearings of this subject, there can be no doubt that there will be at any rate an unanimous consent to enter fairly and fully upon the underlying question of need, and to face, in the most open and unreserved way, the first count of Colonel Strange's indictment. It will be apparent, from the mere title of the paper which was read at the Meeting of the Association by Colonel Strange, namely, "On the necessity for *State Intervention* to secure the Progress of Physical Science," that he has quite made up his own mind that it will be abundantly apparent there is the need, and that there is but one way in which that need can be promptly and efficiently supplied. But from the discussion which followed upon the reading of the paper, it was obvious there are men of high purpose and clear thought in the ranks of British Philosophy who are conscious of the need, but who do not now feel that there is but one way in which the defect can be remedied, and the deficiency supplied. It is therefore imperative that in the first instance the investigation shall be entered upon in the broadest and most cosmopolitan spirit, and that the evidence sought shall be of the freest and most exhaustive character.

In the face of the course that has been determined upon by the Committee of the Mathematical and Physical Section, and by the Council of the British Association for the Advancement of Science, it would be both presumptuous and premature to venture any decided opinion as to either of the questions that are to be made the subject of consideration. But there are certain views of the matter that rise to the surface, out of the arguments that have been already advanced in the preliminary handling of the question, which it will be found advantageous at once to fix as clearly and definitely as possible in the public mind, in order that there may be no unnecessary confusion and misapprehension in regard to the main issue.

In the first instance it must be distinctly understood that even in the extremest form and scope of Colonel Strange's plea there is really nothing that is "revolutionary," or even fundamentally new. In practice, mankind has been already constrained to admit that there is absolute need for "state intervention" in carrying forward the work of scientific investigation. It is out of this absolute need, and of mankind's all but universal recognition of it, that have arisen state observatories for astronomical research. All such astronomical investigations as require sustained and continuous systematic observation, as for instance, the construction of planetary tables, the perfection of the lunar theory, and even the cataloguing of the stars, have been carried on through the intervention of state establishments. No one, even for a passing moment, doubts that in these particulars the mode of carrying on the work has been an advantageous one. Indeed it is not possible for even the most ardent imagination to conceive that the results which have been arrived at in these especial departments could have been secured in any other way. It would certainly be worth while to ascertain the opinion of the Astronomer Royal as to what, in all human probability, those results would have been if all labour of this class had been left to private ardour and enterprise; if such things as tables of the moon had been exclusively contributed by some few dozens of private observers, each following his own notion of the best way of observing and the most convenient way of reducing.

But state intervention has not been confined even to this high branch of scientific labour. It has been in reality found that there are various other departments of intellectual investigation that can only be carried on by the same operation. All the great measures of the earth have been "interventions" of the state, and not contributions of private enterprise. To the state is due all that has been done for preserving in uncontaminated integrity the national standards of length, weight, and capacity. What private or simply co-operative agency could have secured the result which has been already attained at Bloomsbury and South Kensington? To say nothing of the obvious future of the magnificent collections that are gathered in the national museums located there. The influence for good, of the School of Mines in Jermyn Street is now widely recognized and accepted, and that certainly is an establishment that could not have been organized and supported otherwise than by the state. The Kew Observatory, although not a state institution, is a very noteworthy instance on the same side of the argument. It proves, in the first place, the excellent result of substituting organization for desultory individual effort. Before its creation efficient instruments for delicate meteorological and magnetic investigation were scarcely to be procured. It is now the generally recognized authority for the verification of such instruments, and in addition to this main work, other very refined and important investigations are carried on there, which certainly would not be undertaken by individual enterprise; as, for instance, researches relating to the freezing-point of mercury, the rotation of discs in vacuo, and the record by photographic agency of important features presented in the sun's face. Now, this year it has only been found possible to devote the paltry sum of 600*l*. to the support of this useful institution. Who would hesitate to say that in this case usefulness is limited by income, and that under the enjoyment of a more adequate provision from the state, the services rendered to the community at large by this observatory would be very largely increased?

It may thus then be taken for granted that the abstract question, whether scientific investigation shall be aided, and even carried on, by the state in Great Britain, has been already settled by the irresistible verdict of circumstances. It has been found that certain most valuable and important results can only be secured by this agency, and so soon as the nation has been educated to the point of perceiving that those results are wanted for its service, the agency is set to work. All that remains now to be determined is, whether as much has been done in this direction as the best interests of the nation require, when a keen competition has been established between the foremost nations of the world in this particular; whether there is any special and definite line by which an influence, so grandly beneficial in its results where it has been tried, shall be limited in its application.

But in approaching this portion of the consideration, there is one very curious point that has risen into some prominence, as a direct consequence of the discussion having been opened out at the Meeting of the British Association at Norwich; the difficulty, namely, which there seems to be of getting men generally to understand that the want now urged is not a portion of that larger want of a provision of scientific education for the masses as a portion of general instruction. Almost every person who spoke at the Meeting of the British Association fell into this confusion, and argued one way or the other upon the educational ground, although the originator of the discussion had most clearly and definitely limited his meaning and object in this particular by the statement that "there should be established a system of national institutions for the sole purpose of advancing science by practical research, *quite apart from teaching it.*" It seems as if, in consequence of the popular agitation that has recently arisen for the introduction of scientific subjects into general education, men at once jump to the conclusion, when anything at all is said about advancing science, that this is the thing that must be meant. It cannot, however, be too clearly comprehended that these two matters, the "*teaching*" and the "*advancing*" science, are entirely distinct. They are allies in the great work of human improvement, and touch upon each other's limits at certain points, in a friendly way, but they are intrinsically and essentially distinct both in their objects and methods. A student in science has to be taught the leading elements, or it may even be all the elements known at the time of the teaching. It would be inexpedient, even if it were practicable, to tell him of researches still in progress. The necessity of the case requires that his attention shall be strictly confined to what is held to be certain and known. The teacher of science, on this account, has to go year after year through the same course of instruction, scarcely varied or touched by the action of current discovery, and the appliances which his especial work requires are comparatively limited, because they are unvarying, and have to be used over and over again. It is even questionable whether the mind of the formal teacher does not to some extent take the mould of his labours, and become a little stationary and disinclined to forward movement. The cultivator of science, on the other hand, commences his action at the point where the student leaves off. He is, in fact, the student emancipated from the trammels and leading-strings of the teacher. He has ceased to ask, "How is such a thing known?" and in the place of the question adopts the declaration, "Such and such things are not known, and must be ascertained." From copying, and repeating, and verifying, he turns to *creating*. The two processes, the teaching and the extending of science, cannot really be advantageously carried out by the same persons or by the same means. That the two things *are* practically recognized as distinct, is sufficiently proved by the fact that up to the present time we have had no scientific education in England, although we have had great scientific activity, and have effected great, although insufficient scientific progress.

It is obvious that the extensive, or general adoption of science as one of the branches of formal education for the people, will tend to increase the number of persons who will subsequently incline to enter upon the labours of investigation, and that, in this way, scientific education does indirectly favour scientific research. Some competent authorities, indeed, hold that teaching is a direct aid to the cultivator of science, because it keeps him well up in elementary knowledge and stimulates him to the discovery of new proofs and illustrations, and because it brings him into frequent contact with fresh and vigorous, though partially cultivated minds. If this be so, it is clear that the teaching of the cultivator of science would not be the teaching that is contemplated in the routine of scientific education, properly so called. It must be applied in advanced classes only, organized and arranged to ensure the special advantage without profuse and wasteful expenditure of energy, worthy of higher and better employment.

The way in which increased facilties for extending the bounds of human science must influence scientific teaching is too manifest to need that more than a passing word should be devoted to its consideration. Every great fact drawn by the investigator from the unfathomed immensity of the unknown, is a contribution made to scientific teaching through all lands, and for all time. But besides this the augmentation of facilities for prosecuting scientific research will naturally render the student of science more earnest and more willing in placing himself, through the advantages of formal education, in the position from which independent research may be advantageously entered upon. Indeed, it may be roundly said, that a very considerable portion of the efforts of scientific education will have been made wastefully and uselessly, unless the best men who have been inclined to scientfic investigation by their teaching, are enabled to follow out the bent of their inclination through some door especially opened on their behalf.

It has been shown that the influence of the state has been recognized in Great Britain as a legitimate and wise means of securing to the community the advantage of certain scientific operations that could not be carried on with effect by any other instrumentality in the existing state of society. The argument built upon this fact is very largely strengthened when it is remarked, that the same necessity is not only recognized and acted upon by other civilized and enlightened states, but that for the most part such other states much exceed Great Britain in the liberality and even munificence with which they furnish organizations and material means for the prosecution of scientific research. It is matter of the most familiar remark and comment in what a princely way observatories of all kinds are equipped and supported in Russia. But perhaps the most telling instance that could be adduced in this particular, would be the magnificent Chemical Laboratory just completed at Berlin, from Professor Hoffmann's designs. The building has been erected by the Government, at a cost of about 50,000*l.* It is an ornamental red brick structure, enriched with terra-cotta decorations, and medallions presenting the features of men who have played distinguished parts in the science of chemistry. The building consists of two quadrangles, so arranged as to secure most efficient lighting everywhere. The lecture theatre is sufficiently capacious to accommodate between 300 and 400 persons; but it is at the same time a completely equipped laboratory in itself. There are other laboratories within the structure for ordinary and for advanced students; and several laboratories for men pursuing specific branches of investigation. One very large and complete laboratory is reserved for the Professor's own use. The weighing rooms are distinct chambers, efficiently cut off from the fumes of the laboratories by intervening spaces. The galvanic batteries are held in glass cases, provided with flues to carry off the corrosive vapours. Powerful air-pumps exhaust a large series of receivers arranged along the wall. The most complete spaciousness prevails everywhere, and great care has been taken to secure the possibility of extension as necessity arises. The primary object of this splendid institution is to afford not only facilities for the students of the university, but the offering ready opportunity for original research is distinctly recognized in the design. It would be well worth while to institute a comparison between this princely building deemed necessary by our enlightened German neighbours for the encouragement of chemical research, and the sole attempts that have been made by ourselves in the same direction, namely, the Laboratory of the School of Mines in Jermyn Street, and perhaps the Royal College of Chemistry, which is almost a national establishment.

It is pretty generally understood that our colonial dependencies for the most part consider that they are yet too young to have much to do with the cares of providing means for the encouragement or prosecution of science. There is a constant tendency in their free-and-easy life to scatter and spread rather than to concentrate. So long as there are millions of acres of unoccupied wastes just beyond the outposts of the last appropriated settlements, asking men to come and possess them, our colonists hold that it is not necessary for them to trouble themselves about the progress of science. This is so much the case, that the great leviathan prototype of colonization, the Transatlantic Republic, even now distinctly avows that its own proper functions are to diffuse, rather than to create; to send the wave of civilization onward into the wilderness, rather than to increase its depth or force. If this be so, it is a correlative consequence of the position that lands otherwise circumstanced, as is the case with the British Isles, where there is a rapidly increasing population but a rigidly limited territory and no room for overflow, must especially take to themselves the work of creation, and aim at standing in the van in that particular mode of developing and applying power to which small islands are adapted by the actual exigencies of their existence. For this reason alone "Great Britain," of all the nations of the earth, ought to be the most munificent and cordial patron of science in any and in every form, as the one beneficent genius to whom it has owed so much of its "*greatness*," and to whom alone it can look for the preservation of its greatness on its sea-girt throne in time to come. Yet in the face of this obvious consideration there arises the remarkable circumstance, that at the present time Great Britain has not a single first-class telescope at work with adequate optical power for the refined investigations that are now pressing upon the notice of the astronomer, while one of her colonial dependencies in the opposite hemisphere has just completed an instrument of this class at large public outlay. In all probability results will be secured in the spectroscopic analysis of the light of faint stars that fail to show spectral signs to smaller instruments, through this enlightened act of the Melbourne Government, which will give further point to the argument now on hand.

It is an important peculiarity of science, viewed as a branch of human pursuit and industry, that there is literally no limit to either the objects of investigation or the necessity for continuous inquiry. Phenomena of apparently the most trivial character commonly prove to be the first steps to deductions and discoveries that revolutionize the conditions of civilized society. Every point that occurs as involving some insufficiently examined element, must be viewed as a herald that promises to increase and compact man's knowledge of law and his power over material nature. No one who had chanced to observe the Bologna Professor of Anatomy's pretty and apparently somewhat puerile dealing with the contractions of dead frogs, could ever have conceived that there was in those experiments the first step towards the utilization of a power which was waiting the bidding of human intelligence to cover the earth with a network of instantaneous communication, and to enable men to converse and consult together with safety and ease, while boisterous oceans of thousands of miles' span were heaving between them. If the lead of Galvani's experiment had not been tracked out as it was, electric telegraphy would most probably still have been an art of the future. But if there had been in Galvani's days more adequate provision for seizing and following out that lead, it is equally probable that the Atlantic would have been bridged by the electric cable at a still earlier date in human history, and that men would have been now gathering harvest from the discovery that is not yet attainable. No one who watched the philosophers of Newton's day, amusing themselves with the production of the rainbow spectrum from coloured light, could have conceived that the little prism of glass was an instrument capable, in the hands of more modern philosophy and more advanced intelligence, of actually sounding the material conditions of the worlds and suns of space, severed from man's theatre of action by such awful voids that the mind of the investigator yet fails altogether to realize the extent of the span through which the investigation is conducted. No one who then looked at the little prism could have imagined that by it the secrets of the sun's fires were to be revealed —that by it the red flames of the total Solar Eclipse, then only observable during about six minutes at rare intervals, would be turned into objects of daily and continuous study and record,—that by it the proper motion of the remote fixed star, which was rushing directly away from the observer, would be detected and measured. Yet all this has now been accomplished by the application of the prism to the Spectroscope, and it is manifest to every thoughtful mind that this wonderful instrument is only yet on the threshold of a mighty career.

But it should be at once understood that, whilst every point of suggestion and possible investigation should be eagerly seized and surely tracked, a natural division of the labour is fixed by circumstance. There are investigations quite sure to be provided for by individual taste and enterprise; while there are others that necessarily require forethought and organization, and that will never be carried out unless they are insured in some way by the action and at the cost of the general community. The exact line of this practical distinction will, in all probability, be found to be settled by the need for expensive appliances, permanently appropriated buildings, and continuous action steadily sustained through long periods. These are the conditions which private enterprise cannot and, excepting in the rarest instances, will not provide, and which will not be furnished unless they are supplied on the urgent call of an enlightened community sensible of their need. To take as one prominent instance of the field that has to be occupied by system and organization: How numerous are the sustained investigations that are required into the properties of the various materials employed in the useful arts! Who can yet explain the thousand forms which are assumed by iron, and the thousand changes the metal undergoes under the slightest variety of handling? all of which have direct bearings upon the economies, and, in these recent days of multiplied marvels, even upon the safety of human life. The ordinary alloys of the mechanic—brass, gun-metal, bell-metal, and their congeners,—are all universally cast by the rule of thumb. Upon a recent occasion, when it was found to be highly desirable to introduce large castings of aluminium bronze into the frames of the large theodolites prepared to bear the strain of central stations of observation in the Indian Geodetical Survey, this was done to a considerable degree with the most promising effect, but it was found to be absolutely impracticable to carry the principle out to the desired extent, on account of the want of all appliances for dealing with such masses of a new alloy. In yet higher branches of the application of science, man is still more in the dark. The most intelligent mechanics at this moment know literally nothing as to what is the best material for the construction of the linear measures, on the truthfulness of which all the value of geodetical measures depends; neither can they say whether any material that can be employed for this purpose will retain its dimensions and co-efficient of expansion unaltered through long intervals of time. This one investigation alone requires a special building devoted to the task, and long years of close, continuous, and systematic observation. If there were such a thing as a building properly devised and prepared for investigating generally the properties of the metals, fresh work and useful results would never fail it, so long as metals are used by man. The course that has been taken by the Prussians in forming the Hoffmann Laboratory at Berlin is certainly one which may be accepted as an example of one way in which the forward movement of science may be quickened without entailing any risk of doing harm as well as good. If buildings designed for special work were placed not in, but accessibly near, to the largest and most important towns of the kingdom, combining in their construction the four prime essentials of rigid stability, free command of light, provision for the maintenance of any required temperature, and quietude, so that they could be used by all who could show that they had really work to do in them, the cost of their establishment would most certainly very soon be returned manifold to the community.

For the thinkers and social philosophers of England should never lose sight of one great fact that underlies this question, and certainly will continue so to do under all circumstances and events; —namely, that scientific work richly pays the community, but *does not pay the man.* Upon the whole it may be said that the chief discoveries in human knowledge are made by individuals who labour hard at some daily drudgery for a livelihood, and then spend their savings and, as innumerable dark pages of human history show, too often something beyond their savings, to benefit their kind, carrying, as their own reward for the work, privation and impoverishment to the brink of early graves. It certainly is no very rash or bold step to assume that something is wanting in social arrangements where this has to be said of a nation that is at the present time adding millions of pounds sterling every year to its accumulated wealth, in the main drawn from improvements in science.

The large world of scientific men, properly so called, are upon the whole ripe for the recognition of the need for some kind of increased facility for carrying on severe research. This is at once apparent whenever the topic is introduced in general conversation. The main point of difficulty, so far as scientific men are concerned, is the question of the best means of doing what is admitted to be so imperatively called for. Many in the ranks of science believe that the work would be most surely and most satisfactorily performed by the Government, and that it even could be efficiently performed by no other agency. Others, on the contrary, conceive that scientific men can manage their own affairs best, without any extraneous interference, and that any meddling of the state would tend to cripple and lethargize, rather than to quicken and strengthen. There is obviously much to be said on both sides in this particular bearing; and it is therefore well that the issue should be fairly joined, and that much should be said, as now certainly will be the case.

The objection of scientific men to state action seems, however, principally to rest on a threefold ground. There seems to be a sort of general notion that statesmen do not know much about science. Added to this there is the strong fear that if the state subsidized and directed scientific investigation, science would work in leading-strings, instead of in the absolute freedom which is the first condition of her own being, the very breath of her life. And then again there is the notion that where the state has a finger there will be patronage, and preference of inferior agents, who have the support of friendly recommendations, to superior agents who are standing alone.

In regard to this point of view it will not be necessary to say more at present, than that these objections are all properly applicable to state "*maladministration,*" rather than to state *action.* The notion that the government of an enlightened community should concern itself with facilitating and quickening the knowledge and intelligence of the people, of course presumes that the government is to be one that is in every sense worthy of the important trust. There can be no doubt that if a government is not worthy of this great trust, and is not capable of carrying out this important object, it is not worthy of being held to be a government at all. A writer in a recent number of the 'Student' has very tersely and admirably touched upon this aspect of the matter, and has given pointed expression to the true principle that has to be looked to in regard to it. He says, "As civilization advances, and political liberty extends, hostile distinctions between governments and people pass away, and nations tend to organize themselves as great co-operative societies, turning the central power in any direction consistent with individual rights, and likely to be productive of general good. *There ought to be no fear of investing properly constituted governments with too much power of being useful,* though there may be great necessity for constituting efficient safeguards and checks against abuse. Human progress is not likely to diminish the sphere of state action, but, on the contrary, to increase it." It is surely true that in few branches of state action have the evils alluded to less to be feared than in relation to the adoption of formal measures for the extension of science. So far as the experiment has been tried, there has been ample guarantee that where science is concerned, distinction and acknowledged ability do outweigh all other influences and considerations of whatever kind, and to an extent certainly not encountered in other departments of the public service. It is enough in illustration of this to point to the names that are found at the head of four important departments where circumstances have compelled a considerable amount of state action. An Airey directs the National Observatory. An Owen looks after the Natural History Collections of Bloomsbury. A Hooker, after years of tried and arduous labour among the Himalayas, is the presiding spirit of the treasures and glories of Kew; and in the young Mineralogical School in Jermyn Street are encountered such names as Murchison, Warrington Smyth, and Huxley.

It should also most certainly be remembered that in one particular sense science-extension enjoys a remarkable immunity from danger of noxious contamination, issuing from state contact, even over its near relative, science-education. It is fairly within the scope of an ardent and timid imagination to conceive that a state might attempt to indoctrinate the national mind with a certain foregone and foredetermined scheme, adapted to work towards some set purpose; but it certainly is not possible to imagine the utter absurdity of a state influencing the direction of discovery, or shaping the perceptions of new truth.

On the whole, then, the investigation which will now be formally entered upon, and which will be pressed upon public attention, will be pretty much compressed into a nutshell, and will take one clear practical issue. At a time when the surface deposits and surface leads of the great mine of theoretical and practical science are almost exhausted by individual pickers, are deep diggings to be opened out by the aid of a small driblet of the capital that has been created from the past yieldings of the property? Are civilized nations, and especially is England, where there is such isolation and concentration of life and mind-energy, to remain content to benefit by small accidental waifs and strays of discovery that fall in from time to time; or is a clear, powerful, and organized effort to be made to use the present accumulation of human intelligence as a means of quickening the acquisition of that thorough knowledge of the properties and workings of material nature, which is the essence of civilization, and the instrument by which the well-being, the high dignity, and the happiness of the human race are worked out?

VI. THE GREAT SOLAR ECLIPSE OF AUGUST 18, 1868.

By William Crookes, F.R.S., &c., Editor.

The phenomena attending a total eclipse of the sun have always been of a most impressive character, but only within a comparatively recent period have they been observed systematically, and still more recently looked forward to as an opportunity for solving many important problems in solar physics. Previous to 1860, our knowledge of the physical constitution of the sun was based almost exclusively on theoretical grounds. In that year, however, a somewhat important eclipse of the sun occurred, the line of totality passing over Spain, and expeditions from different countries were organized to observe it. The most important of these was that taken from England by Dr. Warren De la Rue, who especially devoted himself to securing photographic records of the progress of the eclipse. The point on which information was principally sought was the physical constitution of the red protuberances, for

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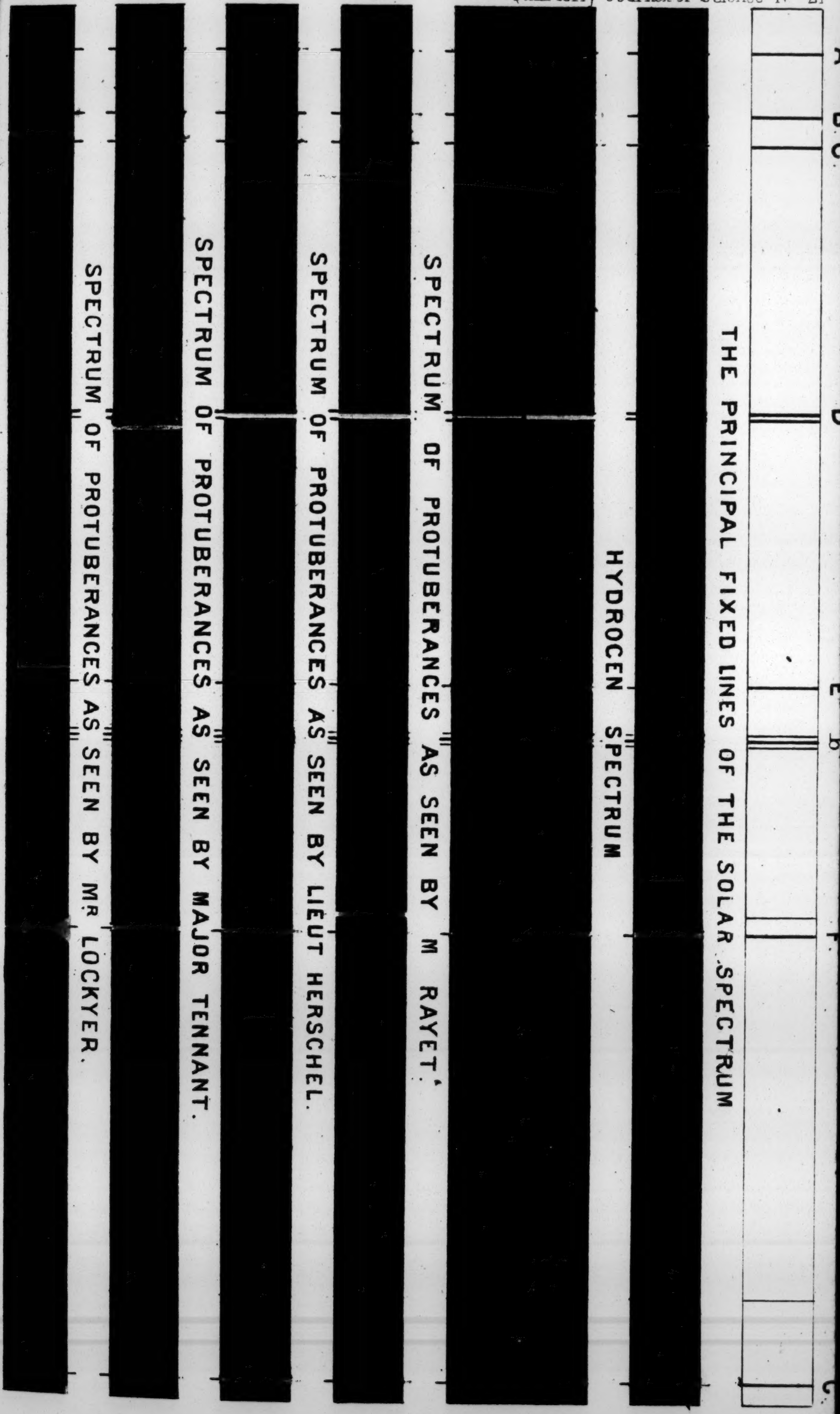
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THE PRINCIPAL FIXED LINES OF THE SOLAR SPECTRUM
HYDROGEN SPECTRUM
SPECTRUM OF PROTUBERANCES AS SEEN BY M RAYET.
SPECTRUM OF PROTUBERANCES AS SEEN BY LIEUT HERSCHEL.
SPECTRUM OF PROTUBERANCES AS SEEN BY MAJOR TENNANT.
SPECTRUM OF PROTUBERANCES AS SEEN BY MR LOCKYER.

TO ILLUSTRATE ARTICLE ON THE GREAT SOLAR ECLIPSE

hitherto opinions had been divided as to whether they belonged to the sun, the moon, or were the results of refraction, &c., in our own atmosphere. The highly successful photographs taken by Dr. De la Rue solved this point, and proved conclusively that the prominences belonged to the sun. But these photographs, whilst they solved one point, raised other problems even more perplexing. Assuming that the prominences belonged to the sun, it had been taken for granted that they were of the nature of mountains projecting from the solar disc, but the photograph showed us enormous masses of matter, well defined and sharp in their outline, but of a size and shape perfectly incompatible with solidity, and hanging suspended several thousand miles above the surface of the sun. Instead of being settled by the 1860 eclipse, the problem was in reality only started, and astronomers, chemists, and physicists, have been looking forward eagerly to the opportunities offered last August to advance some steps nearer its solution.

It seems as if a combination of interesting researches in several branches of science culminated in this one eclipse. Simultaneously with the definite statement of the problem by the photographs, the attention of the scientific world was forcibly directed to a new instrument of physical research—the spectroscope—which was destined to afford a complete answer to the main question. The admirable researches of Bunsen and Kirchhoff* led to the general prosecution of spectroscopic research, and paved the way for the discoveries of Kirchhoff, Foucault, Plucker, Miller, Huggins, and others. The researches, especially of the latter philosopher, on the spectra of the stars, nebulæ, and comets, showed what a powerful instrument the spectroscope would be in researches on solar physics, and especially in the examination of those rare phenomena only to be seen during a total eclipse.

It was accordingly agreed tacitly that spectrum observations were those likely to bear most fruit, and in most of the expeditions which were sent out this year the spectroscope was intended to play an important part.

This great eclipse stands alone in the annals of astronomy. In time of duration (nearly seven minutes at the maximum) it exceeds all recorded eclipses, and more than thirty generations of astronomers will come and go before an equal length of totality will be witnessed. The eclipse observed in Spain only gave the observers 3½ minutes as the longest time in which to concentrate their observations, and it is therefore not surprising that so much anxiety was shown amongst scientific men of all countries to make the most of this grand opportunity.

No single astronomical event has ever before excited such interest. Expeditions were sent half-way across the globe, from England, France, and Germany, and, fitted with all the necessary apparatus, were stationed at different points along the line of totality, from Aden, on the Red Sea, to Wah-Tonne, in the Malay peninsula. Two expeditions were sent from England, one under the auspices of the Royal Society, under Lieut. Herschel, who was to devote himself principally to spectrum observations of the corona and red prominences; the other, from the Royal Astronomical Society, under the charge of Major Tennant. The Royal Society spent nearly 300*l*. for instruments for the expedition; and in case bad weather should interfere with the observations at the principal stations, four hand-spectrum telescopes, similar to those devised by Mr. Huggins for observations of meteors, were also sent out to be distributed to other observers along the central line of the eclipse. The French also sent out two expeditions, one under the charge of M. Janssen, and the other under M. Stephan. Two Prussian expeditions were sent out, and it was also expected that Mr. Pogson, of the Madras Observatory, would also start with a party of observers to some spot along the central line.

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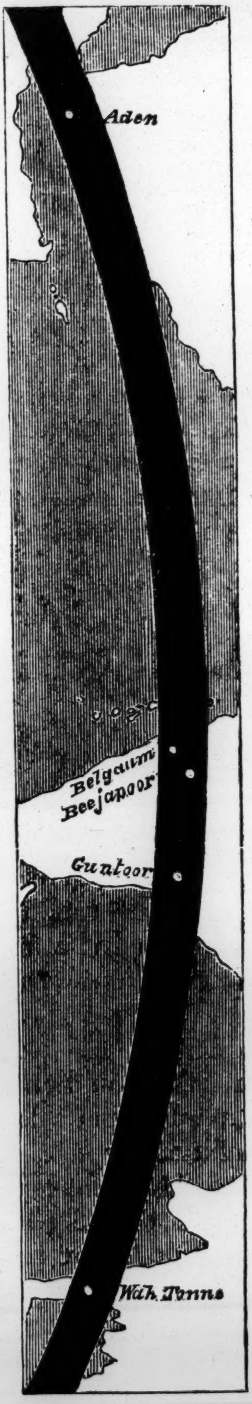
* 'Phil. Mag., August, 1860.

Major Tennant, some considerable time beforehand, computed for the whole breadth of the Indian peninsula the central line and the limits of totality. The shadow is about 143 miles broad, and the line of totality would pass over Kolapoor, Belgaum, Kurnoul, Sikunderabad, Ongole, Guntoor, Masulipatam, Rajah Mandri, the whole course of the Kistna, its Delta, and that of the Godaveri, and parts of the valleys of the Bhuna and Toongabruda. Leaving India proper, the shadow would cross the Bay of Bengal, the north Andaman island, and then pass through the Mergui Archipelago and the province of Tenasserim, across the Malay peninsula to the island of Borneo, which it would reach between our colony of Labuan and the Sarawak country. "Of this course," Major Tennant considered "the west coast of India would be experiencing the south-west monsoon. The same state of things exists at the Andaman Islands, and on the British side of the Malay peninsula. The other side is not easily attainable, and I am not aware that there would be any inducement to go to Borneo. The Eastern part of the track through India affords, I believe, every chance of fine weather, and I think observers would do well to select that part."

In accordance with these suggestions, the North German Expedition stationed themselves at Aden; Lieut. Herschel went to Belgaum; another English party, under Captain Haig, who had been supplied with one of the hand-spectroscopes, was stationed at Beejapoor; whilst the other English expedition under Major Tennant went to Guntoor, at which station the French observers under M. Janssen, who represented the Académie des Sciences and the Bureau des Longitudes, also located themselves; lastly, another French observer, M. Stephan, and party, took their post of observation at Wah-Tonne, on the Peninsula of Malacca. Another German expedition stationed at Moolwar, eighteen miles south of Beejapoor, were unfortunately prevented by clouds from making any observations.

Fig. 1.



The Path of the Eclipse—*August* 18.

Fig. 1 shows the path of the eclipse, the black band covering all places within the line of totality. The different stations are named and left white. Thus the North German observers would secure their results at half-past six in the morning, soon after sunrise, whilst those situated at the more easterly stations would not commence work until several hours later. Most of the expeditions were supplied with photographic apparatus, and it was hoped that by thus securing photographs of the totality, taken at intervals of several hours, it could be ascertained whether the form of the protuberances underwent any perceptible change of shape. The German expedition at Aden and that under Major Tennant at Guntoor were more or less successful in securing photographs, but sufficient time has not yet elapsed to enable any comparative examinations to be made of these.

The principal phenomena which had to be observed (besides the general aspect of the country, the variations in the intensity of light, &c.) were:—

1. Photographic delineations of the phenomena of totality.

2. The position, heights, and general configuration of the red protuberances.

3. The appearance of the corona and its state of polarization.

4. Spectrum observations on the corona and prominences.

These by no means exhaust the list of what was to be observed, but writing after the event, they form convenient headings under which to range the various discoveries. For the sake of convenience, the results of the various expeditions will be collated and described under these several headings.

1. PHOTOGRAPHIC RESULTS.

Judging from the accounts which have come to England, there appears little doubt that the German expedition to Aden was the most successful in this respect. Dr. Vogel, one of the most eminent of the German photographers, had been selected to take charge of this department. His arrangements were admirable in their systematic precision. Possible cases of failure were anticipated, and carefully provided against, and for some time previously all the staff had been engaged in rehearsing the various operations which would have to be gone through during the eventful $2^m\ 55''$ of totality; in short, everything was so well rehearsed, and every one so carefully told off to his duty, that failure from preventible causes was scarcely possible. Aden had been selected as the most likely spot in the zone of totality to be free from clouds; the evening before the eclipse was, however, very cloudy, and occasioned great anxiety, and on the morning of the 18th the sun rose behind thick banks of purple gray cloud; before totality commenced the clouds separated, and enabled four successful photographs to be taken. The apparatus employed was a telescope having an achromatic lens six inches diameter and six feet focus, specially ground by Steinheil, so as to get the photographic image in focus. This afforded a solar image of $\frac{3}{4}$ths of an inch in diameter, and was mounted equatorially and moved by clockwork, adjusted so as to counteract the motion of the earth, and to keep the telescope rigidly fixed on the image during the ten or fifteen seconds required to receive the impression. To the end of the telescope was fixed a small photographic camera, provided with dark slides, each of which would hold a sensitive plate large enough to take two images. The following is the description given by Dr. Vogel of his operations:—

"The totality of the eclipse at Aden was about three minutes long (in India five minutes); nevertheless, we had chosen Aden for our station because there were already photographic observers in India, and because the totality appeared at Aden about an hour earlier than in India. Therefore a comparison of the different results would enable us to decide the question if the protuberances appearing at a total eclipse of the sun were changing in the course of time or not.

"Our task was to get, within these three minutes, as many views of the phenomenon as possible. For this purpose we had previously exercised ourselves in the employment of the photographic telescope, like artillerymen with their guns. Dr. Fritsche prepared the plates in the first tent, Dr. Zenker put the dark slides into the telescope, Dr. Thiell exposed, and I myself developed in the second tent. We ascertained that it was possible in this way to get six images (three plates of two images) during three minutes.

"When the decisive moment was fast advancing, the sky, hitherto covered with clouds, showed some openings, through which the sun, already covered partially by the moon, was to be seen.

"The sun crescent became smaller and smaller, and the opening in the clouds seemed to increase.

"The last minutes before the totality (which began at twenty minutes past six o'clock) went rapidly away. Dr. Fritsche and myself crept into the tents, where we remained, consequently we have seen nothing of the totality. Our work began; we exposed the first plate five and ten seconds, in order to know what was the proper time.

"Muhammed, our black servant, brought the first attempt into my tent. I poured the iron developer over the plate, eager to know what was to come. At this moment my light was extinguished. I called for light, but nobody heard me, as all were about their task. I stretched my right hand out of the tent, holding the dark slide in the left, and happily caught a small oil lamp, which I had previously prepared. And now I saw the image of the sun appearing on the plate. The dark margin of the sun was surrounded by a series of peculiar elevations—the other side showed a strange hook; the phenomenon being exactly the same in both views. My joy was great; but there was no time for enjoyment. I soon received the second, and, after another minute, the third plate. 'The sun is coming forth!' exclaimed Dr. Zenker. The totality was over. All seemed to have been done in a moment.

"When I developed the second plate I perceived only very weak traces of an image. The clouds had veiled the sun at the very moment of the exposure. The third plate gave two brilliant views, with protuberances at the lower margin. Glad to have secured so much, we washed, fixed, and varnished the plates, and immediately took some copies on glass, which were to be dispatched to Europe separately."

FIG. 2.

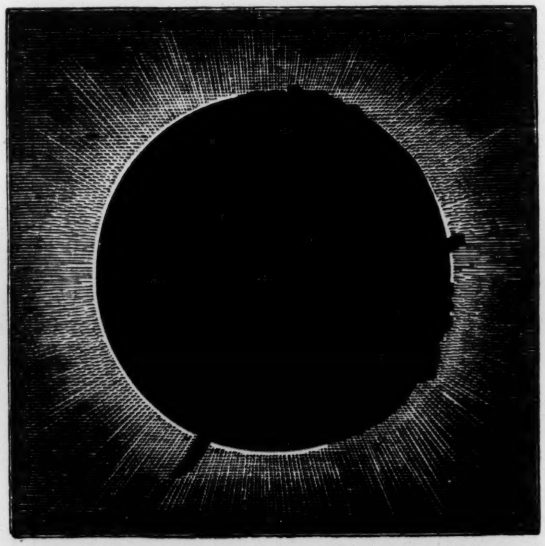


Fig. 2 is copied from these photographs.

The protuberances *a*, *b*, and *c* were given on the first plates, and the protuberances *d*, *e* were shown on the third plate. The great horn *e* is in height about $\frac{1}{14}$th of the sun's diameter, and it would therefore in reality be 12,000 miles high.

Major Tennant, writing from Guntoor, on the day of the eclipse, says:—

"This morning was very promising, and if it had followed the course of its predecessor we should have had a magnificent clear sky, but it clouded over the east with thin cumulostrati, which, while hardly stopping vision, interfere very much with the photographic energy; and the result was that every negative was underexposed, and we have little more than very dense marks showing the protuberances. The six plates arranged for were duly exposed, but the heat so concentrated the nitrate of silver solution that, besides showing but faint traces of any corona, they are all covered with spots. Still, we may make something of them, and will try."

This appears very unsatisfactory; but from a second letter, written five days after, he says that they have since been enlarging the photographs, and he is very well satisfied.

"The clouds reduced the actinism very much and very unequally, but that has shown new things to me. 1st. There is very little corona. 2nd. The cloudy structure of prominences is very marked. But the most remarkable thing is a great horn, which seems to have been 3′ 20″ nearly high. I have, as I told Mr. Airy, clearly seen in its spectrum, C, D, and *b*, and I believe I saw F, but did not identify it. Now this shows both in Nos. 1 and 3 (photographs) as a ribbon of light, coiled spirally round a semi-transparent centre. It is very beautiful, and marked in 3, which was taken two minutes after the (commencement of) totality, and I am doing my best to keep this feature (to retain this feature) in the copies. No. 1 was taken apparently before the last of the sun went. Phillips (one of his assistants) says it was; and there is a spot of fog such as would be the result. There is a fine line of light seen through all this fog much brighter than the corona. This, too, I am keeping on enlarging. We have got six enlarged positives about $2\frac{1}{2}$ inches in diameter from each negative. Every one of these shows the same remarkable spiral structure in the great horn. I find there are traces in a drawing which Dr. Janssen got made of that prominence (mentioned in the first part of his letters as invisible to the eye) of which I spoke. The positive copies I will enlarge to 9 inches."

In a subsequent letter Major Tennant says that the great horn was 90,000 English miles or more in height.

The editor of the 'Photographic News' has commented in very severe terms on these results. He says:—"Our first impulse, on reading such a statement as the result of such an expedition on such an occasion, was to repeat the famous sentence of Ruskin, 'This is not failure, but disaster!' Compared with the results obtained by Mr. Warren De la Rue in Spain, in 1860, compared with those secured by the German Expedition, such an issue as the above is most humiliating. The plates were under-exposed, and covered with spots, we are told, as though the possibility of guarding against such contingencies was a thing undreamt of. This expedition was sent out by the Royal Society, aided by Government, and we fear very much that it is to the aid of the latter much of the failure may be attributed. It is probable, in fact, that it is due to red tape. A staff of men provided by Government might or might not be fitted in all respects for the work; but if the men 'told off' for the duty knew nothing of photography, it would be against all precedent to import a photographer from another department. If the men were selected from the Engineers, and they were not familiar with photographic operations, it would be quite inadmissible to introduce amongst them men from (say) the Artillery, who were skilled photographers. It is probable, from what we can learn, that to a cause of this kind the failure in result was due. Be this as it may, however, it appears tolerably clear that no experienced photographer formed part of the expedition staff, or we should not have heard of such puerile difficulties as spots from concentrations of the silver solution. We have in this country several photographers of high repute and great practical skill, who have had experience in Eastern photography, and who have succeeded amid the gravest difficulties. We refer to such men as Bedford, and Frith, and Goode. Surely it would have been possible to have secured the services of some of these or other experienced photographers to whom the purely photographic operations should have been confided, and who would have certainly secured immunity from the disasters attending concentrated silver solutions, and probably also from the risk of under-exposure."

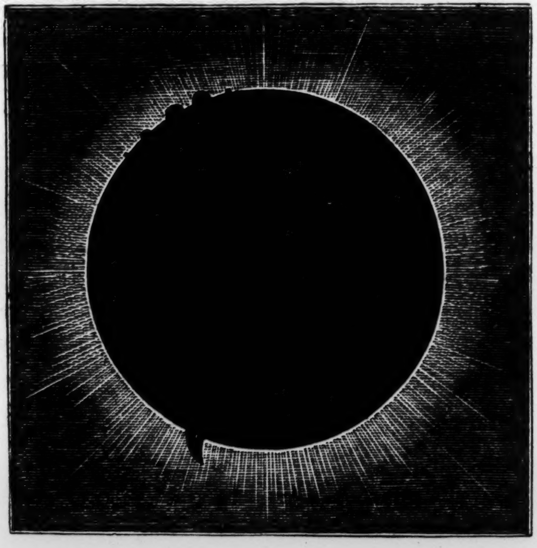
2. THE GENERAL CONFIGURATION OF THE RED PROTUBERANCES.

On this subject an immense amount of information has been accumulated. At Aden Dr. Weiss says that three protuberances were visible during the eclipse, without counting the red border which at the commencement and at the end of the totality encircled wide portions of the lunar limb, and which towards the end appeared surrounded by a deep blue aureola shading off into the sky. The first protuberance appeared very near the point where the last ray of the sun disappeared. Its appearance was that of an agglomeration of protuberances very complicated in its details. The second, the most interesting of all, was located at the eastern border of the lunar disc, rising to a considerable height almost perpendicularly. Its appearance was nearly that of a finger bent in the middle. The third only appeared towards the end of totality in the form of a small conical elevation almost diametrically opposite the first. All these protuberances were of a clear carmine tint and sharply defined.

Dr. T. Oppolzer, one of the observers at Aden, reports that the prominences appeared as if detached from the sun. At the final moment of totality, there was noticed at the spot where the sun was about to reappear, a red border, separated at the last moment from the lunar disc by an intensely luminous space, which formed, as it were, a bridge between the disc and the red border.

Captain Tanner, R.E., who in conjunction with Captain Haig and Mr. Kero Laxuman, observed the eclipse at Beejapoor, has given the following account of his observations. This gentleman is an expert delineator, and occupied himself in making rapid sketches of what he saw. The accompanying drawing (Fig. 3) is copied from Captain Tanner's sketch, who gives the following description of it:—"I at first saw three prominences—one long, curved, pointed tongue, and two close together, straight but flat-topped, about two-thirds the height of the former. They were of a rose-madder colour, and were decidedly more like flames than anything else, not only in their general appearance and colour, but by their being composed of smaller tongues of flame parallel (or nearly so) to the general axis of the flame, so that they had a streaky appearance and a ragged edge. At the first glance, when the sun was somewhat obscured by clouds, I thought they were homogeneous and had hard edges; but this idea was at once dispelled when the clouds cleared off. The two protuberances, which were close together, were not, as far as I could see, joined by any smaller shots of flame. I afterwards observed one small protuberance, and marked the position of it in my sketch. I did not observe that it was streaky, as the others were—perhaps on account of its being so small, and perhaps because I had not sufficient time to examine it properly. As regards the corona

Fig. 3.

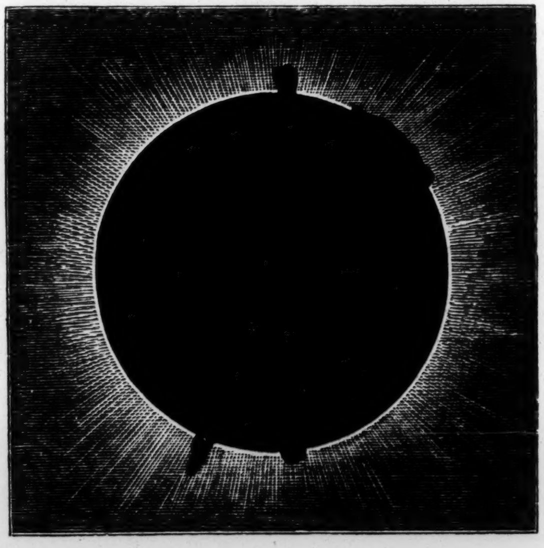


when we first began to see the eclipse through the clouds, I was under the impression that the eclipse, instead of being total, was only annular, so bright was the corona near the moon's limb. I could not detect any irregularities in the structure of the corona, but the light appeared to be gradually shaded off all round."

Dr. Janssen, who was at Guntoor, was principally occupied with spectrum observations, but he gives a very graphic account of the appearance of the long horn, which he says was more than three minutes high, and shone with a splendour difficult to imagine. It recalled the flame of a forge issuing with violence from openings in the fuel, and driven by the force of the blast. The protuberance on the right (the eastern edge) presented the appearance of a collection of snowy mountains, whose base rested on the limb of the moon, and which were illuminated by a setting sun.

The ordinary observations at Wah-Tonne on the protuberances were made by M. Stephan. He examined the phenomena of totality in a large telescope, and describes the protuberances as appearing with marvellous sharpness: they were in four groups, arranged as shown in Fig. 4; their colour was described as rose coral, slightly tinged with violet; they all seemed attached by a perfectly distinct base, and not to float at a certain distance above the sun, as drawn by some observers in recent eclipses. The longest protuberance had a length which was not less than the tenth part of the lunar diameter.

Fig. 4.



During this eclipse it was noticed by more than one observer that the red flames were not extinguished immediately after the totality had passed over. Thus Dr. Weiss, at Aden, said that the large horn remained visible for a minute after the sun had reappeared, being only then lost in the clouds; and Dr. Oppolzer, who was also at Aden, says that this same protuberance could be distinguished for thirty-seven seconds after the last moment of totality. At Beejapoor, Mr. Kero Laxuman describes the great protuberance as like a red flaming torch, streaked by several dark red lines. He says it was visible "for about two minutes after the end of totality, and had there been no clouds I think it could have been seen longer. At Wah-Tonne, M. Stephan records that one of the protuberances remained visible for several seconds after the third contact (the reappearance of the sun). This persistence may seem extraordinary, since the long protuberance did not appear till the second contact; this, however, may be attributed to the fact, that at the third contact the eye was in a state of repose owing to the darkness of totality."

Another curious phenomenon has been recorded by some observers, from which it would appear that close to the surface of the sun there is a highly luminous atmosphere. This is most strikingly described by M. Stephan. He says that the second contact was not followed by a sudden disappearance of all bright light; after the disappearance of the edge of the sun the moon still appeared to M. Tisseraud and himself as if it were surrounded with a narrow luminous border, about a quarter of a minute in thickness, of a brilliancy almost comparable to that of the sun: "this ring is so brilliant that it might lead to an error in the estimation of contact. This luminous ring reappeared some seconds before the third contact. Thus, the actual globe of the sun would appear to be surrounded with a thin diaphanous shell, extremely brilliant."

The captain and officers of the 'Rangoon,' steamship, belonging to the Peninsular and Oriental Steamship Company, which happened to be almost on the central line of totality, have given a very full description, with drawings, of the phenomena observed.

Fig. 5.

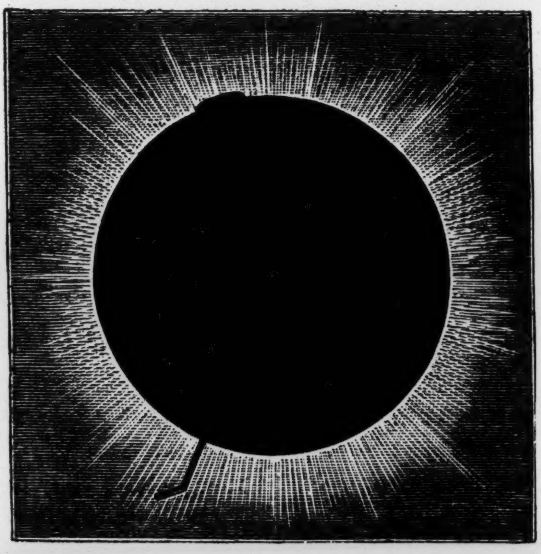
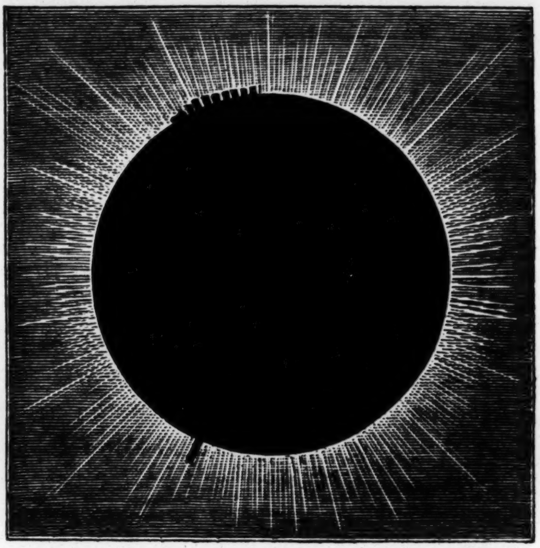


Fig. 5 shows the appearance presented to them soon after the commencement of totality. The long flame was 5′ high, and very brilliant; in the upper portion was another shorter and wider prominence. One of the officers on board says that the long horn became suddenly visible about a minute after the commencement of totality.

Fig. 6 shows the position of the prominences at the reappearance of the sun. The upper prominence disappeared suddenly, but the inferior one remained visible for about ten seconds longer, with its dimensions reduced one-half.

The colour of the prominences is described as different by each observer.

Fig. 6.



Major Tennant describes them as white; Captain Branfill, as coloured; Captain Haig speaks of them as "red flames;" Captain Tanner, as rose madder; Mr. Kero Laxuman, as a red flaming torch, and as red streaked by several darkened lines. Governor Hennessy compares one of them to a tower of rose-coloured clouds, "more beautiful than any rose-colour I ever saw;" another he describes as a bright blue, like a brilliant sapphire with light thrown upon it; next to that was the so-called rose-colour, and at the right corner a sparkling ruby tint.

3. The Phenomena of the Corona.

The state of polarization of the light of the corona was the principal phenomenon which was to be observed, and the results are very concordant.

Lieut. W. M. Campbell, who was stationed at Belgaum with Lieut. Herschel, determined satisfactorily that the light of the corona was polarized in planes passing through the sun's centre. Captain Branfill, who was at Guntoor, made the same observation, and this fact has been further confirmed by the observations made by the French observers.

The accounts received as to the luminosity of the corona vary. Captains Haig and Tanner say that on the first glimpse of the eclipse the corona appeared so bright that it gave them the momentary impression of its being an annular eclipse; and Captain Haig further remarks that the light of the red flames was to the naked eye so feeble as to be outshone to extinction by that of the corona. Governor Hennessy, in the Island of Borneo, speaks of the corona as a luminous ring, composed of a multitude of rays quite irregular in length and in direction; from the upper and lower parts they extended in bands to a distance more than twice the diameter of the sun. Other bands appeared to fall towards one side; but in this there was no regularity, for bands near them fell away apparently towards the other side; they resembled masses of luminous hair in complete disorder; and Lieut. Ray compared them to horses' tails.

Very few spectrum observations were made of the corona, but it apparently gave either no spectrum at all or a very faint continuous spectrum; no bright lines were seen. What few observations appear of value will be found under the next section, as the observations of the corona and the red prominences cannot easily be separated.

It is interesting to observe how the darkness appeared to vary in different places during totality. Captain Haig, near Beejapoor, says that they were surprised to find it so far from total: they could easily write, read writing, and read the seconds of their watches, without the aid of artificial light; in the town, on the contrary, the darkness was so great that it was not possible to see one's own hand; and at Moolwar a gentleman dropped part of an eye-piece of a telescope, and it was not possible to find it, even by placing the eye close to the ground, until after the end of totality. In Borneo, under a cloudless sky, the darkness came on as if a thunderstorm was just about to break: the birds, dragonflies, and butterflies disappeared, and the crickets and cicadæ began to sound; and immediately before the total obscuration the horizon could not be seen; the sky was of a dark leaden blue, and the trees looked almost black; the faces of the observers looked dark, but not pallid or unnatural. The moment of maximum darkness seemed to be immediately before the total obscuration, and for a few seconds nothing could be seen except objects quite close to the observers. Major Tennant says that the darkness was very slight, and the colour not half so gloomy as in the eclipse of 1857, which was partial at Delhi, where he was then.

Venus shone out very brilliantly, and Sirius and several other of the brighter stars were seen, but no mention is made by anyone of Mercury or the supposed intra-mercurial planet Vulcan.

4. SPECTRUM OBSERVATIONS ON THE CORONA AND RED PROMINENCES.

Most fortunately, these observations, which were likely to be of the greatest importance, have been the most uniformly successful. The least satisfactory observation is that of M. J. Rziha, one of the North-German party at Aden; but from the description of the apparatus it was not well fitted for the examination of any special part, and would only give a general spectrum of the whole light received on it. He says that his object was to concentrate on the spectrum the light emanating from the corona during the totality The black lines of the solar spectrum remained perfectly distinct till the commencement of totality, when they disappeared immediately, leaving only a dull spectrum, still always perceptible and continuous. A reversal of the spectrum, that is to say, an appearance of luminous lines in the places occupied by the black lines did not take place. When towards the end of totality, light clouds covered the corona in such a manner as only to allow the light from the red border and that from the protuberances to pass, the spectrum underwent a remarkable change, all the colours of greater refrangibility than the green disappeared, and the red extremity only remained under the form of a spectrum interrupted by wide bands. The first ray of the sun after totality instantly occasioned the reappearance of Fraünhofer's lines.

Amongst the English observers Lieut. Herschel took the most accurate observations. In a letter to Mr. Huggins, dated from Belgaum, he gives the following vivid account of his discovery of the constitution of the red flames:—

"About a quarter of a minute before totality a thick cloud obscured the sun. I had placed the slit of the spectroscope so as to cross the crescent at about the vanishing point of the limb, and was watching the narrow solar spectrum grow rapidly narrower. You may conceive the state of nervous tension at this moment. Whatever the corona was competent to show must in a few seconds have been revealed—unless indeed it should so happen that a prominence should be situated at that precise spot, in which case the double spectrum would be presented. But the solar spectrum faded out while it had still appreciable width, and I knew a cloud was the cause. I went to the finder, removed the dark glass, and waited—in that fever of philosophical impatience which recognizes the futility of irritation, even while it chafes under the knowledge of fleeting seconds—how long I cannot say, perhaps half-a-minute. I can well recall the kind of frenzied temptation to turn screws and look somewhere else, checked by the calm ticking of the clock telling of a firm hold of the right place, cloud or no cloud. Soon the cloud hurried over, following the moon's direction, and therefore revealing first the upper limb, with its radiating and, as I fancied, scintillating corona, and then the lower limb. Instantly I marked a prominence near the needle point in the finder. A rapid turn of the tangent screw covered it with the point of the needle. Those few seconds of unveiling were practically all that I saw of the eclipse as a spectator. The instant the prominence was under the needle point I returned to the spectroscope. A single glance solved the problem in great measure. Three vivid lines—red, orange, blue! No others, no trace of a continuous spectrum. I think I was a little excited about this time, for I shouted quite unnecessarily to my recorder, 'Red, green, yellow,' quite conscious of the fact that I meant orange and blue. I lost no time in applying myself to measurement. And here I hesitate; I have no idea how those five minutes passed so quickly. Clouds were evidently passing continually, for the lines were only visible occasionally. The red must have been less vivid than the orange, for after a short attempt to measure it I passed on to secure the orange, and succeeding to my satisfaction, tried for the blue line. Here I was less successful. The glimpses of light were rarer and feebler, the line itself growing shorter and farther from the cross. I did, however, place the cross very near the true position, and got a reading just as the re-illumination of the field of view informed me that the sun had reappeared on the other limb. I consider there can be no question that the orange line was identical with D (sodium), so far, at least, as the instrument is competent to establish an identity. I also consider that the identity of the blue line with F (hydrogen) is not established; on the contrary, I believe the former is less refracted than F, but not much. With respect to the red line, I hesitate much in assigning an approximate place. It might have been near C (hydrogen). I doubt its being so far as B, but there would be its limits. The corona may have projected a spectrum of some kind, but I saw none."

The observations made by Captain Haig were of less value than those of Lieut. Herschel, being taken with a hand-spectroscope which he had fitted to a small telescope. He reports that he observed the spectra of two red flames close to each other, and in their spectra two broad bright bands quite sharply defined, one rose-madder and the other light golden. Just before emergence, these spectra were soon lost in the spectrum of the moon's edge, which had also two well-defined bright bands (one green and one indigo) about a quarter of the width of the bands in the spectra of the flames, this spectrum being again soon lost in the bright sunlight.

Major Tennant, at Guntoor, was more successful, owing doubtless to his apparatus being more perfect. He reports a continuous spectrum from the corona, and one of bright lines from the prominences examined. He says:—"I am, I believe, safe in saying that three of the lines in the spectrum of the protuberances correspond to C, D, and *b*. I saw a line in the green near F, but I had lost so much time in finding the protuberance (owing to the finder having changed its adjustment since last night), that I lost it in the sunlight before measuring it, and I believe I saw traces of a line in the blue near G, but to see them very clearly involves a very large change in the focus of the telescope, which was out of the question then. "I conclude that my result is that the atmosphere of the sun is mainly of non-luminous (or faintly luminous) gas at a short distance from the limb of the sun. It may have had faintly luminous lines, but I had to open the jaws a good deal to get what I could see at first, and consequently the lines would be diffused somewhat; still I think I should have seen them. The prominence I examined was a very high narrow one, almost, to my eye, like a bit of the sun through a chink in brightness and colour (I could see no tinge of colour), and somewhat zigzagged, like a flash of lightning. It must have been three minutes high, for it was on the preceding side of the sun near the vertex, and was a marked object, both in the last photo-plate just before the sun reappeared, and to the eye."

The French observers seem to have been very successful. M. Janssen, who was furnished with spectrum apparatus of a perfect description, describes the phenomena in the following manner:—"Soon the disc of the sun appeared reduced to a thin luminous crescent. Our attention was redoubled. The jaws of the spectrum apparatus attached to the six-inch telescope were rigorously kept in contact with that portion of the lunar limb which was about to extinguish the last rays of the sun, so that the slit would be led by the moon herself into the lowest regions of the solar atmosphere when the two discs were tangent. The light disappeared all at once, and the spectral phenomena changed at the same time in a very remarkable manner. Two spectra, formed of five or six very brilliant lines, red, yellow, green, blue, violet, occupied the field of view, replacing the solar spectrum which had just disappeared. These spectra, about a minute in height, corresponded ray for ray, and were separated by a black interval, in which I could distinguish no appearance of a brilliant line. The finder showed that these two spectra were due to two magnificent protuberances which shone out to the right and to the left of the line of contact where extinction had just taken place. The preceding observation shows directly:—

"1. The gaseous nature of the protuberances (brilliant spectral rays).

"2. The general similitude of their chemical composition (the spectra corresponding ray for ray).

"3. Their chemical nature (the red and blue rays of their spectra were decidedly C and F of the solar spectrum, characteristic as is known of hydrogen gas)."

The observing party at Wah-Tonne appeared to have been even more successful than M. Janssen, if we may judge from the number of lines seen and identified. M. Rayet had charge of the spectrum apparatus, which consisted of a telescope with a silvered glass mirror 20 centimetres in diameter, mounted equatorially for the latitude of the station, and of a direct vision spectroscope. The latter instrument, formed of three very dispersing prisms, was arranged of short length, and to give much light.

The slit of the spectroscope having been arranged so as to cut at right angles the image of the narrow luminous arc which would remain some seconds before total obscurity, the light from the extremity of the horns was first examined. On the ground of a spectrum with very sharp black lines formed by the diffused atmospherical light was seen a much more luminous band, which was the spectrum of the light emitted by the extremity of the horn. Whatever was the width of this part, nothing particular could be noticed in it; the rays had an appearance in respect to width and intensity identical with those of the ordinary solar spectrum.

The observation of the horns was interrupted some seconds before totality, in order to remove the diaphragms from the telescope, to slightly open the slit of the spectroscope, and thus be prepared to examine the protuberances.

At the instant of total obscurity, the slit of the spectroscope having been brought on to the image of the long protuberance, which became visible on the eastern edge of the sun, M. Rayet immediately saw a series of nine brilliant lines, which, by their arrangement in the field, their relative distance, their colour, and their general effect as a whole, appeared to be related to the principal lines of the solar spectrum—B, D, E, *b*, an unknown line, F, and two lines of the group, G. These lines possessed great brilliancy, and appeared strongly relieved from the ashy grey very pale ground.

During these observations, the slit of the spectroscope was parallel to the principal length of the protuberance. Thus the luminous lines were seen in the apparatus of a length in proportion to the height of the protuberance; the slit having been turned 90° round, the rays appeared reduced to the appearance of brilliant points corresponding to the slight width of the luminous horn; no error of observation is therefore possible, and the brilliant lines actually represent the spectrum of the light of the protuberances.

The spectroscope being in the first position (the slit parallel to the length of the protuberance) the very brilliant lines corresponding to D, E, and F, were seen to be prolonged beyond the mean length, by a very feeble luminous tract, the spectrum presenting the appearance given in the coloured diagram. A certain portion of the incandescent gaseous light which forms the protuberances therefore spreads into the solar atmosphere beyond the limits which the eye in general assigns to these expansions.

The examination of this first protuberance being finished, the slit was directed to the large luminous region at the west of the sun. This time, also, the spectrum was seen to consist of brilliant lines arranged as in the first case, with the exception of there being only one violet line. Therefore all the protuberances do not appear to emit identical light.

It was remarked that the light at the corona was very faint in comparison with that of the protuberances; for whilst the light of the latter gave a very vivid spectrum, the corona, in spite of the rather large opening of the slit, did not give any appreciably coloured spectrum.

In the coloured lithograph which accompanied this article, the artist has endeavoured to reproduce as closely as possible the various spectra observed at the different stations. The upper plain one gives the positions of the principal fixed lines in the solar spectrum, the second spectrum consisting of three coloured lines on a black ground, represents the spectrum of incandescent hydrogen. Below that will be seen the lines observed by M. Rayet, with the faint prolongations of E, F, and G spoken of above. The one below that represents the spectrum seen by Lieut. Herschel, and that observed by Major Tennant follows. When this plate was prepared, no detailed description of Janssen's spectrum had been received, except that the lines seen were principally those of hydrogen. The two lower spectra will be referred to immediately.

We come now to a very remarkable double discovery which inaugurates a field of investigation, destined to produce a rich harvest of discovery in solar physics. Two years ago, Mr. Norman Lockyer communicated to the Royal Society a paper, in which he showed how the spectroscope could be employed to decide the claims of two theories as to the cause of sun-spots; and in the concluding paragraph he remarked:*—"May not the spectroscope afford us evidence of the existence of the red flames which total eclipses have revealed to us in the sun's atmosphere; although they escape all other methods of observation at other times? And if so, may we not learn something from this of the recent outburst of the star in Corona?" This was not a chance suggestion, for Mr. Lockyer had been engaged in sweeping round the sun's edge and over its disc with his spectrum apparatus, in the hopes of detecting such a spectrum revelation, but owing to imperfect apparatus no result was for a long time obtained. Another observer, Mr. Stone, met with no better success; and Mr. Huggins, as late as May, 1868, had unsuccessfully put the same idea to the test of experiment. The train of reasoning is sufficiently obvious: the spectroscope alters the relative brilliancy of two spectra, one of which consists of a few isolated luminous rays, the other being continuous from red to violet. The light of the continuous spectrum may be fanned out by a system of prisms, so as to weaken the rays to any desired extent by distribution over a large area, whereas the same amount of dispersion merely places the luminous bands of the former spectrum farther apart, without weakening them to any extent. If therefore the red flames gave a spectrum of bright lines, they would become visible by examination under sufficient dispersive power. Mr. Lockyer, satisfied that his want of success was owing to deficient power or want of adjustment in his instrument, applied himself to construct a more powerful spectroscope, which was completed in October last. With this he was soon rewarded by the sight of a prominence spectrum, an account of which was forwarded to the Royal Society, on October 20th, in the following words:—"I have this morning perfectly succeeded in obtaining and observing part of the spectrum of a solar prominence. As a result I have established the existence of three bright lines in the following positions:—

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* 'Proceedings of the Royal Society,' Oct., 11, 1866, vol. xv., p. 256.

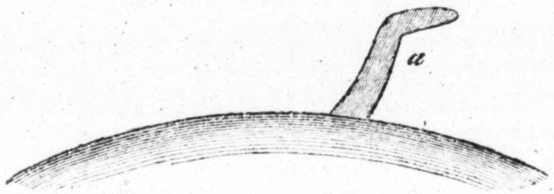
I. Absolutely coincident with C.
II. Nearly coincident with F.
III. Near D.

"The third line (the one near D) is more refrangible than the more refrangible of the two darkest lines, by eight or nine degrees of Kirchhoff's scale."

In a subsequent communication to Dr. De la Rue, Mr. Lockyer says that he has been able to recognize that the protuberances are simply local accumulations of a gaseous envelope, which completely surrounds the sun, for in all parts of the circumference he perceives the characteristic spectrum of the protuberances. The thickness of this new envelope is said to be nearly 5000 miles, and it is marvelously regular in its contour, at the pole as at the equator. A prominence gives a spectrum consisting of a few long bright lines, but on directing the instrument to the extreme edge of the sun, and with the slit perpendicular to its tangent, a narrow belt of the true solar spectrum is seen, fringed with that of the new envelope, consisting of a few very short bright lines projected on a very faint continuous spectrum of diffused daylight. The bright lines being superposed on or forming a prolongation of the solar spectrum, it is easy to ascertain with great accuracy whether they coincide with any of Fraünhofer's lines; the dark line sometimes being obliterated and at other times being prolonged by the bright one. If the instrument adjusted in this manner to the extreme edge of the sun be now gradually swept round the circle, when a prominence is reached the narrow spectrum of the chromosphere, as Mr. Lockyer has termed his new solar envelope, begins to lengthen, and by measuring the length of the luminous lines in different parts of the circle, it is easy to map out the shape and position of the red flames almost as accurately as if the observer had the benefit of a perpetual eclipse.

In this manner Mr. Lockyer has sketched the protuberance shown in the following figure:—

Fig. 7.



When the slit is adjusted so as to fall on *a*, the brilliant rays are seen entirely separated from the solar spectrum.

We come now to the curious duplex nature of this discovery. In describing his spectrum observations of the eclipse prominences of the 18th August last, M. Janssen said:—

"The most important result of these observations is the discovery of a method of which the principle was conceived during the eclipse itself, and which will allow of the study of protuberances and of the regions surrounding the sun at all times, without its being necessary to have recourse to the interposition of an opaque body before the sun's disc. This method is founded upon the spectral properties of the light of the protuberances—light which resolves itself into a small number of very luminous pencils, corresponding to the obscure rays of the solar spectrum."

M. Janssen describes his discovery in the following words:—"It struck me immediately that it would be possible to see the rays without an eclipse. During the night the method and means of execution were clearly arranged in my mind. The next morning, the 19th, the sun rose very brightly. By means of the finder attached to the large telescope, I placed the slit of the spectroscope in part on the solar disc, and part beyond; the slit therefore gave two spectra, that of the sun, and that of the region of the protuberances. The brilliancy of the solar spectrum was a great difficulty, I therefore turned the apparatus so as to remove from the field the red, green, and blue, the most brilliant portions of the solar spectrum. All my attention was directed to the line C which was dark in the sun's spectrum, but brilliant in that of the protuberance. Suddenly I perceived a small brilliant red ray, one or two minutes in height, forming a rigorous prolongation of the black line G of the solar spectrum. Upon moving the slit of the spectroscope in such a manner as to sweep methodically the region that I was examining, this line was persistent, but it became modified in length and in the brilliancy of its various parts, thus showing great variations in the height and luminous power of the different regions of the protuberance. Shortly afterwards I perceived that the brilliant ray F was visible as well as G. In the afternoon I returned to the region examined in the morning; the brilliant lines showed that great changes had taken place in the distribution of the matter of the protuberances; the lines were sometimes broken into isolated parts which were not united with the principal line in spite of the movements of the exploring slit. This fact indicated the existence of isolated clouds which had been formed during the morning."

The conclusion of M. Janssen's report contains two interesting facts, the first is that the lines of the protuberances penetrate into the black lines of the solar spectrum, thus demonstrating the prolongation of the protuberances on to the globe of the sun. The second is that the protuberances become altered in shape and displaced with extreme rapidity. On the 4th of September a remarkable observation is recorded, showing that a mass of matter many hundred times larger than the earth is in a few moments displaced and completely altered in form.

This discovery of M. Janssen's was strangely enough communicated to the French Academy only a few minutes after Dr. De la Rue had communicated Mr. Lockyer's discovery to the same body; it had before been communicated to the Royal Society. As Mr. Balfour Stewart remarks:—"Although the priority of observation is due to M. Janssen, yet the possibility of the discovery was suggested by Mr. Lockyer more than two years ago, and to my knowledge he has been working at it since that time; whereas M. Janssen frankly acknowledges that the idea only occurred to him during the eclipse itself. This fact was very nobly referred to by M. Faye, at the discussion which followed the announcement of the discovery at the Academy of Sciences."

It would appear as if these luminous lines were somewhat variable in their appearance, some being present in one protuberance and not in others. The temperature and intensity of action going on over the sun's surface have also much to do with their appearance; thus Mr. Lockyer has occasionally detected a new C line, a little less refrangible than C by the distance apart of the two D lines, apparently caused by an ejection of extraneous matter. A curious phenomenon has also occasionally been observed with the F line, it sometimes exhibits a widening at the base or in some other portion of its length, suggesting the explanation that with great increase of temperature the ray of light of this refrangibility becomes nebulous and capable of spreading sideways, in the same way as the yellow sodium lines will do. No other line has been observed to do this.

In the coloured illustration the lowest spectrum shows Mr.

Lockyer's new C line and the abnormal appearance of F. The one above it shows the general appearance of his prominence spectra.

This discovery is being actively followed up, and the Rev. Father Secchi has already communicated to the French Academy two papers on the subject in which Mr. Lockyer's discoveries are in every respect confirmed.

In the absence of detailed official statements from the principal observers, it is difficult to sum up accurately the results of these spectrum observations, although there is no doubt that the scientific gains have been immense. All except Captain Haig directed their spectroscopes to the long horn which forms so prominent an object in all the diagrams given, and which appears to have been connected with one of the solar spots. Major Tennant speaks of it as a vast flame of incandescent hydrogen, magnesium, and sodium vapour, and considering that all the lines of these elements were seen by one or other of the observers during the eclipse, and that Mr. Lockyer and Father Secchi have since proved the presence of the hydrogen lines, there is little doubt that these three elements—hydrogen, sodium, and magnesium—actually do exist in a gaseous and incandescent state in the circumsolar atmosphere.

Since the discovery that the red flames (as we are entitled to call them now) can be examined at any time the sun is visible, the extreme interest with which physicists have hitherto looked forward to a total eclipse will be somewhat abated. It may, however, be worth recording that, on the 7th August next, there will be a total eclipse of the sun visible in North America. The path of totality, about one hundred miles in width, will pass through Alaska, lat. 60° 46·9′ north, long. 68° 4·6′ west of Washington, on Saturday noon; crossing British America, it will again enter the United States territory near the head of Milk River, long. 30° W., pass through the south-west corner of Minnesota, crossing the Mississippi river near Burlington, Iowa, the state of Illinois just north of Springfield, and the Ohio river near Louisville. From thence it will run, in a south-easterly direction, through the states of Kentucky and North Carolina, and reach the Atlantic Ocean near Beaufort, North Carolina, at about sunset. North and south of this line the eclipse will be partial throughout the United States.

The American photographers are already organizing arrangements to bring every available telescope into use on that occasion for photographic purposes, and intend securing photographs along as many points of the path as possible.

The writer, who has already had some experience in photographing the phenomena of eclipses, the moon and sun, would venture to make three suggestions in this respect. Firstly, that attention should not exclusively be confined to the wet collodion process, but that the daguerreotype and dry albumen process should also be used. Pictures by these processes possess more sharpness, and are capable of giving more microscopic detail, than ordinary wet collodion; moreover, the plates may be prepared the night before and developed after the eclipse is over, thus leaving the operator's whole attention free to devote to the exposure of as many plates as possible.

Secondly, some telescopes should have a system of lenses beyond the principal focus of the object-glass, so as to project a magnified image of the phenomena on to the sensitive plate. The necessary amplification to four or five inches will be far more accurately done when effected in this manner at one operation than when the small negatives are copied afterwards in the enlarging camera, which will magnify all the defects as well as that which is wished to be recorded.

Thirdly, the most experienced photographer who can be obtained should have charge of the photographic operations. It is a mistake to suppose that astronomers, physicists, and photographers can be manufactured for the occasion. To look at the records of the English expeditions, it would appear as if the highest scientific talent possessed by the country were an exclusive attribute of our army and navy. Amongst so many captains and lieutenants it is a relief to find a plain Mr. The French and German expeditions were managed differently—and contrast their results with ours!

VII. THE SCIENTIFIC YEAR.

If we examine with thoughtful attention the progress of human knowledge, as it is preserved to us in the history of civilization, or in the records of the victories achieved by mind over matter, we cannot fail to observe that it has ever been by slow, and often intermittent steps. The energies of the individual mind, even in the most healthful state, cannot be maintained continuously at the same elevation; the powers of thought cannot be kept long at the same state of tension. There must be a lowering down, there must be a relaxation. As it is with the powers of the individual, so is it with the aggregated forces of the mind of mankind. The law of undulations, which is so beautifully manifested in all its subtleties of motion, in the phenomena of light, and the other physical powers in motion, is shadowed forth in the movements of intellectual power with so defined an outline, that we cannot but regard it as a truth, obscure at present through the many difficulties by which all psychological phenomena are surrounded, through the imperfections of our senses, and through the almost entire absence amongst men, of that cultivation which the inquiry demands. If, however, we will be at the trouble of carefully investigating the history of any discovery, it will be found that, from the first thought,—usually as obscure as the remotest gleanings of nebulous matter,—there have been advances, as if by throbs; periods of action, and seasons of repose, something of brightness being gained by each manifestation of power, until, eventually, the cloudy thoughts gather into rings of brightness, and the disconnected members coalesce into a perfect truth, an ever-abiding and a perfect star.

Electricity is an example of this. We have now the most subtile of the physical powers completely under our control, and we compel it to melt and mould our metals, to blast our rocks, and fire our cannon, to illuminate the ocean around our dangerous shores, and to travel earth and ocean as our Mercury—with fleeter wings than he who was the messenger to the gods. Many men, boasting of the march-of-intellect-age,—of the achievements of science,—regard this as the work of to-day—and with much vanity, and but little truth, refer all this to the efforts of the living race—forgetting that three thousand years have been expended in developing the laws of this power, which is now our familiar slave. *Electron* (amber); the powers of attraction and repulsion possessed by it, and also by the Iron-stone of Magnesia, were known to the Greeks; but Electricity and Magnetism were for ages mysteries, unfolding, as it were, by spasms until in the fulness of time the great truth shone forth.

Heat and Light exhibit similar phases, and show like periods of brightness and of eclipse. Through the dream-land of Alchymy, Chemistry slowly struggled into being, and Astrology, after ages of error, which often presented features of an almost sublime grandeur in its robes of superstition, brought forth the most perfect of the sciences—Astronomy. These facts have been referred to only as showing how small must be the record of real advance within any single year, seeing that so large a period of time is necessary for the development of one simple truth.

The year 1868 cannot be regarded, in any way, as an exceptional one. Indeed, it appears upon a careful examination of the "Chronicles" of progress to fall rather below the average of the past twenty years. There has been a considerable display of industry, and the result of that industry is shown by the accumulation of facts. The perceptive powers have been active, and, of material phenomena new to our consciousness, there have certainly been some notable discoveries, but the evidence is wanting which should show that man's reflecting powers have been largely exercised in the philosophic task of generalization. The materials have been gathered together from the right hand and from the left, they have been carefully named, and placed in order for use, but the master-mind, to whom is reserved the privilege, to whom is given the power, to construct from those fragmentary truths a systematic whole, is still wanting.

The year may be regarded as one peculiarly inductive. There has been great earnestness amongst the disciples who are devoted to the watching of the lamps which burn in the many shrines within the temple of truth, and many varieties of the constituent parts of the fuel, by which the flames are fed, have been collected by them; but the generalizing mind,—the deductive philosopher,—by whom alone those fragmentary facts can be concreted into a complete whole, has not appeared. The evidences, however, of this will be far more satisfactory to the thoughtful reader than any expression of opinion by the writer of this notice. We shall, therefore, endeavour very briefly to sketch out the more striking facts which have been gained during the year, and indicate, where we can, the paths along which advances may be expected to be made.

Nothing within the range of the sciences of observation can be more satisfactory than the records of Astronomy, especially as it respects the extended observations on the flights of meteors, the spectroscopic analysis of the nebulæ and of the stars, and the investigation of the luminous excrescences observed during the period of total obscuration upon the edge of the eclipsed sun. The shooting star, "a moment bright, then gone for ever," has long been regarded as an interesting phenomenon; but who amongst even the wisest, in past years, dreamed of the remarkable truths which are now opening upon us? By the careful record of all the facts which could be gathered together respecting the appearance, and the characters of those meteors, we have advanced our knowledge in a remarkable manner, and there appears to be no reason for doubting the conclusions at which our observers have arrived, that many belts of meteors are moving with planetary regularity within the limits of the solar system. The most remarkable of those belts is made known to us by the "November flight." The beautiful—almost sublime—meteoric showers, which have been seen about the 14th of that month, have a duration of about five hours. The earth traverses the meteor stratum in space at the rate of 18,000 miles an hour; consequently, this gives us an expanse of 90,000 miles, more or less densely filled with those mysterious bodies. The maximum of intensity of the meteoric bursts lasts but about an hour; within that period these "shooting stars" have been counted by hundreds. How thickly, therefore, must that—probably the central line—of the bed be strewn with them. The part traversed by the earth varies by millions of miles from year to year; therefore, as each November brings again a recurrence of the phenomena, we have the proof that the meteor zone must be continuous, but that it varies in density. The vastness of these accumulations, the clearly proved periodicity of these star showers, leading to the conclusion, that a considerable number of meteor belts are regularly crossed by the earth in her annual rotation, are amongst the most exalting exercises for the human mind to linger on. The meteor zone is now regarded as an enormous oval hoop in space, extending far out beyond the orbit of Uranus, and this zone, like an elastic belt, has been shown to be disturbed by vast vibrations, probably the result of planetary attractions. By one of these great undulations the meteors have been brought unexpectedly into view this year, when their return was not expected. Of the part played by those small masses of matter in the phenomena of the universe, we know nothing; and we can only hope to establish firmly the hypothesis of that seeming stratification, to which reference has been made, by close observations extended over many years. The supposed relation, too, of these meteoric belts to the orbits of certain comets, opens out a vast field for speculation, and demands the most cautious observations. The fine hypothesis, or rather philosophic speculation of Hock, on the phenomena of swarms of meteor corpuscules, crowding from space into the solar system is, only named to show how much we require to be guided by the severest laws of induction in considering this tempting subject.

The delicacy of Spectroscopic analysis can never fail to excite a large share of attention. During the year the examination of the nebulæ with the spectroscope has given strength to the reasons for supposing that the light by which we discover the gaseous nebulæ is emitted from nitrogen and hydrogen. This beautiful instrument has told us other truths. By it we are enabled to measure the rate at which the earth passes through the waves of light reaching it from any source; and we have discovered, with high probability, that the nebulæ are not moving towards or receding from us, but that the bright star Sirius is approaching the solar system at the rate of nearly 29½ miles in every second of time. Of all the discoveries of the year, however, no one is more remarkable than that addition to Solar Science, (which is certainly peculiarly the science of our own age,) so recently made by Mr. Lockyer and M. Janssen, which informs us that the red prominences which have been observed during several total eclipses of the sun are luminous gaseous matter, giving in the spectroscope the lines which belong to burning hydrogen, with an indication of some other substance, probably new to us, although there are suspicions that it may be carbon. It is nearly thirty years since several experimental photographers drew attention to the fact that the solar spectra obtained by them gave evidence of some peculiar protecting influence existing around the edge of the sun—that is, that light of a different character emanated from the edge of the solar orb, from that which was radiated from the centre of the disc. Beyond the mere fact, nothing could be satisfactorily made out of this; but now we have in all probability a key to the solution of the problem.

Mr. Stone's discussion of the observations made in 1769 on the transit of Venus, leading to a correction of the sun's distance from us, which he determines to be 91,000,000 instead of 95,000,000 miles, shows the degree of exactness which is now attainable in astronomical calculations. The most remarkable feature of the astronomy of the day is the intense desire to test by the utmost severities of analytical science the correctness of observed facts. We have shown how valuable the spectroscope has been to the astronomer. As an instrument of research in the hands of the chemist, it has not of late proved strikingly profitable. There are many observers who, by determining with all possible exactness the character and positions of the dark lines of the solar spectrum, and the bright lines of flame spectra, are doing most valuable work for future use; but, with the few new metals discovered by its aid, there has been a repose which is not easy of explanation. Chemistry has indeed put aside, as it were, for a season its analytical labours, and the science now dwells with delight amidst its synthetical achievements, which, it must be admitted, are beautiful, curious, and seductive. It is to be feared that the beauty of the laws which regulate the composition of compound bodies, and the pleasure of producing either new organic substances or of forming well-known ones by the discovery of novel methods for effecting the intercombination of elements, may lead men away from the more valuable analytical investigation of Nature's own productions. The changes which may be rung upon a peal of bells are absolutely insignificant in comparison to the number of bodies which might be produced by the intercombination of the known elements. An alchymist—one of the last of his race—after contemplating the multitude of created things, and the discoveries of his still imperfect science—said, "I marvel not that God has created so many things, but rather that He did not, from the material at His command, create an infinitely greater number." The present phase of chemical science will no doubt give place eventually to one of more exact investigation than heretofore, and enlarged generalizations. That industry and mental skill which is now given to nomenclature and notation, will be employed in the higher labours of working out those problems upon the solution of which depends our knowledge of natural phenomena, and our power of applying such knowledge to the useful purposes of life. Chemistry is the handmaid to all the natural sciences; hence, as to astronomy, so to geology does she lend her valuable aid.

The discussion "On Chemical Geology," which has excited much attention, and which has been carried on with great skill by two well-trained experimentalists and philosophers, leaves us at the end exactly where we were at the beginning. "Going back to the earliest forms of created matter" is launching a frail bark at once into all the doubts and difficulties of the nebular hypotheses and cosmical fancies;—it is plunging into a dark dreamland, in which there is ample room and verge enough for the play of the most volant and erratic imagination, but from which we are not likely to gather any guiding truths. As exercises for well-trained minds, who desire something, as the phrase goes, "to break upon," such speculations are all very well. But if the same mental labour—the same chemical skill—had been bestowed on the things of to-day, instead of on the speculative conditions of the beginning, which can never be determined, the world would have reaped an advantage which is now exceedingly problematical. From Chemical Geology it is but a step to Geology itself. The year has not produced any discovery of great novelty, but it has given evidence of the industry of our geologists. The discovery of Eozoon in the Laurentian rocks of Canada was of great interest. One of the most important discoveries recently made in Palæontological Science is analagous with it. It is the detection of what appears to be the remains of a terrestrial flora, in certain Swedish rocks of Lower Cambrian age—the supposed equivalents of our Longmynd rocks. A peculiar interest attaches to this discovery, inasmuch as it carries back the appearance of terrestrial vegetation upon the earth's surface through a vast interval of time, no land plants having previously been known older than the Upper Ludlow beds. The Swedish fossils now discovered appear to be the stems and long parallel-veined leaves of monocotyledonous plants, somewhat allied to the grasses and rushes of the present day. These plants apparently grew on the margin of shallow waters, and were buried in sand and silt. Although it is probable that several species and even genera may occur in the sandstone blocks which have been examined, they are provisionally included in a single species, to which the name of *Eophyton Linnæaum* has been given. Eophyton, therefore, stands by the side of Eozoon—the one being, in the present state of our knowledge, the earliest land plant, as the other is the earliest animal organism. Our Chronicles will give the details of this interesting discovery, which cannot find a place in a sketch of yearly progress. Reference to these important records — notes for the future historian of the progress of scientific knowledge—will show that many questions of considerable importance to the future of geological science are being discussed with much earnestness. In most cases a decision can only be arrived at after the most cautious examination of extensive districts of country. It is to be regretted that in some of the discussions which have during the year excited attention, there has been more evidence of a desire for victory than for the elimination of truth.

Physical Science has its numerous workers, who, devoting themselves to its various branches, are opening out roads to future discoveries which will possibly be of considerable importance. The examination of the radiant powers is being followed up with much zeal, and many trained minds, peculiarly fitted by nature for the work, are eagerly seeking for the solution of many problems which still remain unsolved in relation to heat and light radiations and electrical manifestations. Without for a moment venturing to question the truth of the undulatory theory (the weight of talent and testimony brought to bear on it is too overpowering to admit of that), we cannot but express a fear that the interpretation of some of the phenomena of solar radiations has been retarded, by refusing to see any explanation save that which belongs to wave-motion. To this circumstance may be referred the almost entire absence of research on the chemical powers of sunshine. Many important facts, as they now stand, do not *appear* to come within the law of undulations (they may possibly be shown to do so), and hence they have been put aside. Thus one of the most fertile fields of inquiry—the chemical activity of the solar radiations (ACTINISM)—rich with the promise of discoveries of high value, is entirely neglected by the experimentalists of the present day. This is, it must be admitted, partly due to another circumstance. As soon as the chemical action of the sun's rays had been rendered so familiar to the most untrained operator that he could, from the sensibility and simplicity of the processes given to him, scarcely fail to produce a photographic picture of much excellence, and the science became an art, the scientific investigator drew aside, as though he disliked to admit that he was seeking after truth for its money value. Here is, however, a vast inquiry bearing in a direct and remarkable manner on organic growth and on inorganic combination, which lies fallow.

The investigations on the Osmose forces advance certainly towards a solution of the mysteries of molecular attraction, and particularly of the phenomena of the action of surfaces. The indications of an uncontrollable power, dissimilar to any of the physical forces already named, are unmistakable. A power—a force—which can overcome the gigantic attraction of the earth's gravitation, and which can break up, by mere mechanical effort, the strongest chemical affinities, must be amongst the most potential of the physical agencies. At present it appears to us that the full value has not been given to the discoveries made by Graham, Deville, and others in this direction. A remarkable series of facts has been accumulated; they have been investigated with the most perfect appliances of induction; and the results cannot be gainsayed. Many years cannot roll away before the power of deduction must be brought to bear in all its strength upon this gathering; and the generalization of the true philosopher must evoke a new and mighty spirit from the charmed circle, and bind it to do man's bidding

The physical sciences have been sought to aid the investigations of the physiological student, and some striking facts have been recorded, showing how necessary it is to examine the phenomena of organization in relation with the operation of the physical agencies, Light, Heat, and Electricity, and the laws which regulate chemical affinity.

Zoology and Botany, Mineralogy and Crystallography, have, during the year, been worked, as it were, in obedience to the same law which has regulated the progress of the other branches of science. Inductive inquiry has been the rule, deductive generalization the exception. Archæology, Ethnology, and Philology have been progressing—we hope with a greatly improved system of inquiry. The poetry of the past is gradually disappearing before a rigid spirit of inquiry, and the history of man, as preserved to us in his works and in his words, is being won from the grave, from mounds, from the caverns, and the lake-dwellings of buried ages.

In this brief sketch it has been our object to show that valuable facts have been gathered during the past year, and that much intelligence and industry has been expended in carefully labelling those treasures and arranging them for future use. The study of names has been cultivated, to the injury, we believe, of the more enlarged culture of ideas. Still, arguing from the past, through the present, to the future, we are convinced that the time is not far distant when the accumulated materials will be, by the efforts of some philosophic mind, converted—probably by one gigantic effort—into a structure beautiful in its truth and holiness.

We are advancing steadily towards a realization of the fact that mind, and mind only, is the ultimate source of power. No mechanical, no physical energy can be available for good to man without the concurrence of mind. Every practical application of science is a sermon on this text—Mind is the master of Matter. We live under the "Reign of Law;" but every fact discovered, every speculation of any value uttered, carries forward the never-to-be-controverted truth that Law cannot be without a Law-Giver—consequently, that all the laws which the mind of man is steadily evoking from the arcana of space and time, are the material manifestations of the energies of one Almighty mind.

R. H.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

1. AGRICULTURE,

And Recent Agricultural Literature.

A GOOD example of the serviceableness of the chemist, rather as the critic and commentator than as the guide of the agriculturist, occurs in the recently published volume of the 'English Agricultural Society's Journal.' The clover plant removes from the soil large quantities of those substances on which its fertility is generally supposed to depend. It takes, indeed, according to Dr. Voelcker, in the paper to which we refer, more potash, phosphoric acid, lime, and other mineral matters which enter into the composition of our cultivated plants, than any other crop usually grown in this country. How obviously, then, must it be for the interest of the wheat crop, that the clover which precedes it on the land should be consumed where it grows, grazed and depastured by sheep or other animals, so that the substance of the crop may be returned to the soil from which it came, instead of being cut for forage and taken green to the feeding-house or stable, or mown for hay, or harvested when its seed has ripened—being in all these cases altogether taken from the land. The ash constituents of the plant would thus be ready for the crop succeeding it, instead of merely enriching the general dung-heap of the farm, to be applied elsewhere. It is, however, the fact, not only that the clover plant, which takes so much nutriment from the land, is the best possible preparation for wheat, but that the wheat crop is better after a clover crop cut and carried off the land than after clover fed upon the field where it has grown. This, of course, was not at all to have been expected, but Dr. Voelcker, modestly taking his facts from the actual experience of the farmer, instead of enforcing a necessarily imperfect theory as the corrective of mistaken practice, finds on investigation a sufficient explanation of them in the following circumstances, by which, of course, the theory of the subject must for the future be limited and modified. During the growth of clover a large amount of nitrogenous matter accumulates in the soil. This is due partly to the decaying leaves, dropped during the growth of the crop, and partly to an abundance of roots, which are stronger and more numerous when clover is grown for seed than when it is mown for hay, and also when it is mown for hay than when it is fed off by sheep. The nitrogenous matters in the clover-remains are, on their gradual decay, finally transformed into nitrates, thus affording a continuous source of food on which cereal crops especially delight to grow. That the clover plant which robs the soil is, nevertheless, a fertilizer of it, is illustrated in every example of a failing clover crop. We remember seeing on the wheat field of a farm near Oxford deficient strips stretching parallel across the land, which were explained by the fact that the clover seed-barrow had here and there missed; so that, whereas elsewhere the contents both of subsoil and of atmosphere had, by a vigorous plant of clover, been accumulated within the surface soil for the benefit of next year's wheat crop, here the subsoil and the air, robbed by no clover plant, had contributed nothing of their abundance, and the surface soil was proportionally the worse. The same truth tells to some extent on the comparison of a clover crop fed off with one allowed to ripen; for the development of roots, being checked when the produce in a green state is fed off by sheep, in all probability then leaves less nitrogenous matter in the soil than when clover is allowed to get riper, and is mown for hay. And this, no doubt, accounts for the observation made by practical men that, notwithstanding the return of the produce in the sheep excrements, when the clover is fed off green by sheep, wheat is generally stronger, and yields better after clover mown for hay. We are quoting Dr. Voelcker's words as well as his conclusions; and the whole research appears to us a notable example of the way in which the scientific man can most serviceably discuss farm practice for the benefit of the farmer.

Among the other papers in the current number of the 'English Agricultural Society's Journal' is one by Messrs. Lawes and Gilbert, on the "Home Produce, Imports, and Consumption of Wheat," to which attention should be directed. It shows that the average produce of small experimental plots of wheat upon the Rothamsted Farm, under the three several circumstances of "no manure," "continuous dressings of farmyard dung," and "continued dressings of various artificial manures," is a perfectly trustworthy guide to the character of the crops generally throughout the kingdom. It illustrates the fact that the growth of wheat has of late years gradually diminished in this country, having fallen in England from 3,400,000 acres in 1850 to 3,140,000 acres in 1867, and in Scotland from 210,000 acres in 1854–57 to 110,000 in 1866–67. The average produce of this crop per acre is the subject of detailed discussion, and the following are the figures arrived at as true of the last sixteen years:—

AVERAGE ACREABLE PRODUCE OF WHEAT.

England and Wales	$28\frac{3}{4}$	bushels	per acre.
Scotland	$27\frac{3}{4}$	"	"
Great Britain	$28\frac{5}{8}$	"	"
Ireland	$23\frac{7}{8}$	"	"
United Kingdom	$28\frac{1}{4}$	"	"

Among the other facts to which this elaborate paper leads we may quote the following:—That the average annual consumption of wheat per head of the population is about $6\frac{1}{3}$ bushels in England and Wales, scarcely $4\frac{1}{4}$ bushels in Scotland, and only about $3\frac{1}{3}$ bushels in Ireland; or for the whole of Great Britain about 6 bushels, and for the whole of the United Kingdom about $5\frac{1}{2}$ bushels per head. Taking the population of the United Kingdom to be about 30,800,000, and the average consumption of wheat to be $5\frac{1}{2}$ bushels per head, this gives a present requirement of rather more than 21,000,000 quarters annually. And with a reasonable theory both of the increase in population and of the gradual increase of consumption per head, the requirements of the country may be no less than 23,000,000 quarters annually five years hence. Unless, then, the home produce of the country shall largely increase, there will be required over the next five years an average importation of between nine and ten million quarters of wheat per annum.

We may mention as illustrative of that change of cropping to which Mr. Lawes in his discussion of this subject had adverted, that the practice of taking barley in immediate succession to wheat upon the land is gradually increasing; being justified, first, of course, by the fact that good crops are thus obtainable, but also, as compared with what was thought good practice years ago, by the increased facilities both of efficient tillage and liberal manuring which English farmers now possess. By the aid of steam cultivation, thorough autumn tillage is now of easy accomplishment; whilst, though the wheat crop taken after beans, and still more after clover, which itself succeeds a grain crop, very often leaves a stubble foul and needing fallowing, yet in ordinary seasons there is ample opportunity for a thorough cleansing of the land before the winter; and as regards manuring, our guanos and superphosphates enable the farmer to keep the land stocked with fertilizing substances, however it be cropped. Thus Mr. C. S. Read, M.P., at the Norwich Meeting of the British Association for the Advancement of Science, declared:—"I have this year, with a dressing of 1 cwt. of guano and 2 cwt. of superphosphate per acre, grown on a wheat stubble that had been dug 12 inches deep with the steam-cultivator in the autumn the best crop of barley I ever produced, the land being now perfectly clean, and in the best possible condition for next year's root crop. And I see no reason why this extra white straw crop need frighten any land agent, provided always the farm be in a high state of cultivation." During the coming year there will, no doubt, be a good deal of what is thus called cross-cropping; owing to the need of keeping clovers for another year, for the young clovers have very generally failed, owing to the drought of 1868. But we may say with Mr. Read that there is no need of any fear that the fertility of the land must suffer on their account. In fact, it is now well understood that a farmer may crop the land very nearly as he pleases without injuring the owner of it, provided he uses the means of tillage and manuring which he now possesses, and which his own best interests would lead him to employ.

The cheapening of the superphosphate manufacture, owing to the abundance of mineral phosphate in England, Spain, and Germany, and other countries, is one of the most important facts in the recent history of English agriculture. That which a few years ago cost 6*l.* or 7*l.* a ton, containing only 15 to 18 per cent. of soluble phosphate of lime, is now sold at a price which is virtually one-half less. And it quite deserves a record in an Agricultural Chronicle that the chairman of the South Lincolnshire Tillage Association was able the other day to inform the members that he had completed a contract for the delivery of 1000 tons, containing 26 per cent. of soluble phosphate, at 4*l.* 2*s.* 6*d.* per ton, to be delivered free in bags at any of the Great Northern Railway stations within 80 miles of Lincoln. It must, however, be added on the other side, that in consequence of the large exports of sulphate of ammonia to the sugar-growing districts of Germany and the colonies, all ammoniacal manures are rising in price, guano is commanding its full market value, and sulphate of ammonia in particular has advanced from 12*l.* to 17*l.* 10*s.* per ton.

To turn now to another subject:—The condition of the labourer —a question which we have several times had to name during the past year, as having been urgently pressed upon the public attention by the labours of the Rev. Canon Girdlestone, Mr. Baily Denton, and others, is again brought vividly before the public mind by the recent report of Her Majesty's Commissioners appointed to inquire into the employment of women and children in agriculture. The points in which it seems from their report that the Commissioners expect the best result to follow any active interference on behalf of agricultural labourers, are the provision at a fair rent of allotments of land for cultivation by cottagers, and the cheapening and improvement of the cottages. To the subject of benefit societies, savings banks, &c., they propose referring in a further publication.

It is, of course, impossible to state in a single page the substance of so full a description of the condition of the English agricultural labourer as is given in this blue book, and we must be satisfied therefore with commending it to the careful study of our readers, who will find on its perusal not only how much need there is in the facts of the case for earnest effort everywhere on the part of benevolent men, but also how many benevolent men in all classes of society are earnestly desirous and laborious in the effort that is already everywhere being made.

No account of the agricultural proceedings of the past quarter is at all complete which omits to mention the efforts of local agricultural societies, and the many instructive lectures, papers, and discussions which are thus published, first locally, and then through the agricultural papers generally. Among those of the past few months, we may specify a capital account by Mr. Scott Skirving, before the East Lothian Agricultural Society, of the natural history of the farm, so far as the birds, which are at once the friends and enemies of the farmer, are concerned; also a good report, by Mr. Henderson, of Stirling, before a farmers' club in that neighbourhood, of the relations of the sciences of Geology, Botany, and Chemistry to the practice of the farm. To Mr. C. S. Read, M.P., we owe an excellent report on the improvements of late years in the agriculture of Norfolk, read before the British Association at their last meeting; to Mr. Harding, of Somersetshire, a useful lecture before a Cheshire farmers' club on the cheese manufacture; to Mr. Everett, of Newbury, a paper on the social as well as the directly practical results of small farms and long leases; to Mr. Saunders, of Watercombe, in Dorsetshire, a good paper on roots as food for stock; to Professor Coleman, before the Chamber of Agriculture for the North Riding of Yorkshire, a lecture on artificial manures; to Mr. E. Scrutton, of Borobridge, a report on the implements of the farm; to Mr. Hallett, of Brighton, a history of his own experiments in maintaining the pedigree of cultivated wheat and barley; to Mr. Startin, before the Midland Counties Farmers' Club, a discussion of the incidence of the poor's rate as affecting the character of cottage property; to Mr. Mechi, a discursive and suggestive lecture on the undeveloped character of British agriculture; and to Mr. J. K. Fowler, of Aylesbury, a very excellent history of the influences which railways have exerted in the promotion of agricultural improvement. The two last-named lectures were given before the London Farmers' Club. We have not enumerated a quarter of the subjects which have thus all over the country been made the occasion of vigorous discussion at farmers' meetings, and which agricultural readers find reported at more or less length in the agricultural weekly papers. Certainly, however, the Agricultural Chronicle of the quarter would be altogether imperfect if it had not thus referred to that constant and formal discussion before local societies in every county, of points in the theory and practice of the profession which is almost a distinctive feature of English agriculture, as compared with the other occupations in which Englishmen engage.

A last word may be given to one among the wilder theories which have thus engaged attention, as it has only recently once more presented itself to readers—the so-called "transmutation of grain." Every now and then a farmer relates in perfect good faith that he has sown oats and cut them down repeatedly until, a year, or perhaps a second year thereafter, on permitting them to grow and seed, they have turned out wheat. The recent occurrence of disqualifications at Birmingham and Islington of pigs which had been entered for exhibition—on the ground that an inspection of their teeth showed that they were not all of one family, as the condition of the competition required them to be—enabled the 'Agricultural Gazette' the other day thus to expose the folly of this "transmutation" theory: "Here, in the animal world, where the womb carries but one family at a time, where the birth is notorious, and everything in the whole history of the produce is a matter capable of record and claiming observation, no certainty seems possible; for the young are taken for exhibition, and it is protested by experts that they are of different origin. But the impossibility of any confidence about parentage, which even in our shows of live-stock occasionally occurs, is necessarily multiplied a thousandfold where the mother is the soil, carrying in her fertile womb at once the germs of myriads of families, where the period of gestation is indefinite, and where the facility of new seeds, new germs, being accidentally deposited, is excessive. In the face of risks like these, the occasional stories of Oats being sown, and Wheat being ultimately reaped, go for absolutely nothing. The antecedent improbability of there being any real connection in such a case between the sowing and the reaping is so enormous, that no scientific man would think it worth his while to make an experiment to test it. And certainly the risks of the experiment are so great, that no other than a scientific man is competent to conduct it."

2. ARCHÆOLOGY (PRE-HISTORIC),

And Notices of Recent Archæological Works.

PRE-HISTORIC Archæology received a new impetus when Dr. Hooker, in August last, recalled attention to the semi-savage populations of India which are still erecting megalithic monuments. The importance of the investigations of these cromlechs and dolmens seems, however, to have already aroused attention in India; and in the April number of the 'Proceedings of the Asiatic Society of Bengal' is an interesting paper by Mr. Mulheran, "On the Crosses and Cromlechs which are found in great abundance on both banks of the Godavery, at Katapur, and elsewhere." The cromlechs, in which the remains of either one or two bodies appear to have been interred, usually consist of a number of upright stones sunk in the ground in the form of a square, covered by one or two large slabs of sandstone. They are considered by the author to be of Buddhist origin.

The crosses are of the Latin form, and are made of one piece of stone 10 or 11 feet high, of which about 7 feet are exposed above the ground. They do not appear to have had any connection with the cromlechs, and were probably erected as memorials of the faith of Christians buried in their vicinity.

In a subsequent number of the Proceedings of the same Society, Lieut. J. S. F. Mackenzie reports the discovery of a great number of cromlechs in the vicinity of the town of Veerajpett, in South Coorg. The cromlechs were found covered by large mounds of earth, evidently artificial. One of them consisted of six large stones, surmounted by a huge flat slab, the whole being divided into two compartments by a large centre-stone. The two front slabs had each, at the top and immediately below the superincumbent stone, peculiar apertures of a segmental form, about 2 feet by 1 foot 8 inches. Many other cromlechs were discovered, possessing similar openings, which the natives consider proof of these structures having been the abodes of the pigmy race described in their legends, the apertures having supplied them with the means of ingress and egress. Lieut. Mackenzie, however, considers that these openings were simply used for the purpose of introducing cinerary urns and the bones of the members of the family, as they died one after the other. In these sepultures several antique-shaped urns and pots were discovered, composed of thick red and black highly glazed pottery. Some of the vessels were tripods, while others were supported on four feet. No bones were found in them, either calcined or in their natural condition; but iron weapons were tolerably abundant, and included a spear, some large javelins and arrows, and the hilts of daggers. It is satisfactory to find that upon the discoveries of these remains being made known to the Indian Government, sums of money were granted to carry on the investigations.

During Dr. Erdmann's survey of the Quaternary formations of Sweden,* he has been able to throw considerable light upon the nature and position of the most ancient monuments of that kingdom, which are described as tumuli, runic stones, circles, fortified enclosures, inscriptions traced upon the rocks, dolmens, and sepulchral chambers. The ancient fortified enclosures (borglemningar), ordinarily situated on the summit of an eminence, are often several miles inland, and are composed of one or more concentric walls, constructed of great blocks of stone, some of which are 10 cubic feet in dimension. Within the walls of the enclosure are found traces of habitation; and from time to time, deeply sunk in the mud, at the base of the eminence upon which these hill-forts are situated, the remains of ancient boats have been discovered. Iron rings are also reported to have been found at the bottom of the rock, to which they may have served to moor the boats. There can be little doubt that we have here evidence of the gradual recession of the sea, and that these ancient enclosures, now high and dry, were constructed upon points more or less surrounded by water.

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* 'Exposé des formations Quaternaires de la Suède,' par A. Erdmann.

Two more instalments of the 'Reliquiæ Aquitanicæ' have been issued during the quarter. They are almost entirely occupied by a description of the celebrated cave of Cro-Magnon, situated in the valley of the Vezère, between the village of Les Eyzies and the railway station of that place. The cave, which is 15 mètres above the river, and 73·25 mètres above the sea-level, is formed by a projecting bed of Cretaceous limestone, the *débris* of which forms the lowest bed of the floor. This bed is succeeded by three layers of ashes, separated from one another by thin beds of calcareous *débris*. The uppermost of these is overlain by red earth with bones, which underlies the thickest layer of ashes, bones, &c. The ash-bed is surmounted by a yellowish earth with bones and flints, and that by another bed of hearth-stuff, the rest of the cave being filled up by calcareous *débris* and the rubbish of the talus. From the yellowish earth at the back of the cave the remains of five human skeletons were obtained, of which four have been recognized as belonging to adults (three male and one female), and the other to an immature infant. Associated with these remains were multitudes of perforated marine shells, principally belonging to the common Atlantic species *Littorina littorea*, a worked amulet of ivory pierced with two holes, carved antlers of reindeer, chipped flints, &c. The fauna found associated with the sepulture in this case, and in the layers of hearth-stuff, comprised fourteen or fifteen species of mammals and one bird, and consisted of the remains of an enormous bear, the mammoth, the great cave-lion, the reindeer, the spermophile, &c.,—the bird being possibly referable to the Crane genus. The cave itself, as proved by the occurrence at all levels of flint scrapers, seems to have served at different times as the habitation of the same race of nomadic hunters, who, when the accumulated refuse and *débris* had raised the floor of the cave to an inconvenient height, returned to it only as a place wherein to bury their dead. The skeletons undoubtedly belong to people of the age of the reindeer, and M. Pruner-Bey refers them to his Mongoloid group, and to the Esthonian type. The human remains, both with regard to their condition and to their proportions, exhibit several peculiarities, which space will not permit us to notice.

In the 'Anthropological Review' for October is an article by Professor P. Broca, "On the Ancient Cave-Men of Périgord;" but as the article is only an abridgment of a memoir, which will appear in the 'Reliquiæ Aquitanicæ,' we defer our notice of it until it shall appear in its proper place, stating here, however, that the author considers that we have in the Les Eyzies' skeletons evidence of a tribe, "entirely different from any other race, ancient or modern, that we have ever seen, or heard of."

In the annual report of the Smithsonian Institution for the year 1866 is a paper, by Dr. D. G. Brinton, "On the Artificial Shell-Mounds and Deposits," which occur in great numbers along the south coast of the United States, especially in Georgia and Florida. These mounds consist of the detached valves of *Ostrea Virginica*, *Venus mercenaria*, and *Unio Virginiana*, and contain flint arrow-heads, fragments of pottery, and charcoal. Some of them attain enormous dimensions—one at the mouth of the Altamaha river, covering ten acres of ground, and containing about 80,000 cubic yards. Another, about four miles from the mouth of Crystal river, in the form of a truncated cone, 30 feet in diameter and 40 feet in height, is exclusively composed of oyster-shells and vegetable mould; with forest trees, some of them 4 feet in diameter, growing upon its surface.

The gigantic scale of the mounds serves easily to distinguish them from the Kjökkenmöddings of Denmark, which seldom attain to a height of more than 10 feet. Dr. Brinton considers them to be the work of known tribes of Indians; but, even if it be so, what length of time is required for the gradual accretion of such immense accumulations, and to what purposes were they applied?

In the same report, Mr. C. Ray describes the discovery, on the left bank of the Cahokia creek, at the northern extremity of Illinois town, opposite St. Louis, of a place where the manufacture of earthenware had been carried on by Indians. The pieces of pottery were discovered near an old fosse, and varied from $\frac{1}{8}$th to $\frac{3}{8}$ths of an inch in thickness, according to the size of the vessels. They were made of clay, mixed either with coarsely pulverized Unio shells or siliceous sand, and were coated generally on the exterior, but sometimes on both sides, with a thick layer of paint. The aboriginal potters usually formed their vessels by hand, but in some instances appear to have modelled them in baskets woven of rushes and willows, so as to produce a rough ornamentation. The fragments are decorated with lines, or combinations of lines and dots, and in the majority of cases the edge of the vessel is turned over so as to form a rim, the bottom being rounded or convex. Of the antiquity of this pottery the author is not prepared to give an estimate, although there is little doubt that the manufacturers of it were the Cahokia Indians, who were dwellers on the creek until a comparatively recent period.

The discovery of two "crannoges" in the lake of Ballyhoe, Co. Monaghan, is described by Mr. G. Morant in the 'Proceedings of the Kilkenny Archæological Society' for January, 1867. The drainage of the Glyde river, which runs through the lake, has permanently reduced the level of the water by several feet, leaving exposed upon the shore flint-flakes, knives, scrapers, celts, and arrow and spear heads. Ashes were generally found near the flint implements; and, in one instance, a dark-coloured glass bead, and in another, a *leaden bullet* were discovered associated with flint-flakes. The greater part of the implements were included in the peat, but some were found lying on its surface, and others on its rocky subsoil. On the great "crannoge" was a mound principally composed of ashes, containing sharpening stones, implements of iron, and leaden bullets; on its shore, a bronze pin, and a flint spear-head were found, and from the edge of the lake, close by, were obtained flint arrow-heads, hatchets, &c. Some of the flint implements were highly finished, but others were as rude as those of the Amiens pattern; and Mr. Morant argues from the intermixture of these two types with instruments of bronze and iron, that most of them were used at one and the same time by the same race of men,—the ruder weapons being the implements of the common people, while the more highly-finished arrow-heads and bronze pins were the weapons and ornaments which adorned the persons of the chiefs. The occurrence of leaden bullets certainly points to the comparatively recent occupation of the "crannoge," but archæologists will require a much more careful examination of this lake-island before they will feel convinced that the generally accepted and well-defined ages of stone, bronze, and iron, are confusedly mixed together in the manner described by the author.

Colonel A. Lane Fox has published a very interesting description of "Roovesmore Fort, and Stones inscribed with Oghams, in the parish of Aglish, County Cork." This fort, or "Rath," is in the form of an irregular circle, about 130 feet in diameter, measured from the crest of the innermost parapet; beyond this is a ditch about 17 feet in breadth, and beyond the ditch another parapet of 10 feet base and 3 feet high, the ditch being between the two parapets. This structure was probably a fort, as it is well situated for defence, on the top of a gentle rise, and is nowhere commanded from the outside.

Nearly in the centre of the interior space is the entrance (though probably not the original one) to the crypt, of which every Rath possesses one or more. This crypt appears to have been originally of a quadrangular form. Six upright slabs had been placed as jambs, longitudinally, in two lines, at about two feet from the sides of the chamber. Upon the tops of these, heavy slabs of unhewn stone were laid transversely, as lintels, and upon these again rested other longitudinal slabs of the same kind, placed side by side, the edges nearly touching, so as to form the roof.

The chief interest of Colonel Lane Fox's paper is centred in these last-mentioned slabs, for on examining them from beneath by the light of a candle, he found that two of them which lay contiguous to one another had their edges scored with Oghams. Our space will not allow us to follow the author's interesting description of these marks, nor his arguments in support of the conclusion that they are of *greater antiquity than the building of which they formed part.* We shall have performed our duty as chroniclers by directing attention to the pamphlet, and to the fact that the slabs themselves may now be examined in the British Museum.

Before concluding our Chronicle, we should notice the publication of a second edition of M. le Hon's popular work* on Fossil Man. Besides the addition of the new facts which have been brought to light since the first appearance of the book, considerable space is devoted in this edition to the investigation of the cosmical laws which have brought about the Quaternary and Glacial periods; and to a *résumé*, by Professor G. Omboni, of Darwin's theory, of which he is a warm supporter.

3. ASTRONOMY.

(*Including Proceedings of the Astronomical Society.*)

SINCE our last Chronicle appeared further intelligence has been received respecting the operations of those who went or were sent to view the great eclipse of August 18; but we have little to add to what we then wrote. We now know that the photographic operations of Major Tennant's party were not so successful as the telegram first received had led us to hope. The negatives arranged for were duly exposed, notwithstanding the unfavourable condition of the sky, light cirrus clouds interfering seriously with the photographic energy of the sun. As might be anticipated, the negatives were under-exposed. Owing also to concentration of the nitrate-of-silver solution, resulting from the heat of the climate, the negatives, besides showing but faint traces of the corona, were all covered with spots.

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* 'L'Homme Fossile en Europe.'

The chief fruit of the expeditions has been the discovery that the rose-coloured prominences are gaseous. This discovery has already led to one of the most interesting applications of spectroscopic analysis ever yet made by astronomers.

We must premise that two years ago, in a paper addressed to the Royal Society, Mr. J. Norman Lockyer called attention to the possibility that spectroscopic analysis might avail to exhibit indications of the existence of the coloured prominences. He said, "May not the spectroscope afford an evidence of the existence of the red flames which total eclipses have revealed to us in the sun's atmosphere, although they escape all other methods of observation at other times?" Not content with pointing out this method, Mr. Lockyer applied it to the search for prominences, making use of a spectroscope with which he had already been able to analyze the light of the solar spots. He failed, however, in detecting any traces of the prominences with this instrument; and, indeed, he was led to the conclusion that the prominences are not gaseous. "A diligent spectroscopic analysis," he wrote last July, "has not revealed any bright lines. This is strong negative evidence that they are not masses of incandescent vapour or gas."

So soon, however, as the news from the eclipse expeditions showed that he had come to this conclusion too hastily, he prepared to renew the search with an instrument which was (at the time) being constructed for him by Mr. Browning, the optician; and on the 20th of October he succeeded in detecting the bright line spectrum of a prominence.

But in the meantime, unfortunately for Mr. Lockyer's claim to priority, M. Janssen, who had been one of the first to detect the true nature of the prominences, was led to conceive the notion that their spectra may possibly become visible when the sun is shining with full splendour. He did not lose any time in putting his ideas into practice; for the day after the occurrence of the eclipse he succeeded in observing the spectrum of a prominence. Thus, two months before Mr. Lockyer, he had solved the important problem of "grasping and measuring by spectral analysis phenomena before invisible."

Had M. Janssen sent home intelligence of his success by the same means as he had employed in the matter of his eclipse observations, his claim to the merit of the discovery would have been indisputable. This, however, he did not do. He sent a letter containing an account of his researches, and it happened, singularly enough, that this letter reached the President of the French Academy of Sciences a few minutes after Mr. De la Rue had read before the Academy a detailed account of Mr. Lockyer's researches.

Who is to have the merit of the discovery? As M. Faye remarks, "the priority of the idea belongs to Mr. Lockyer, but that of its fruitful application rests with M. Janssen." He suggests that the honour of the discovery should be accorded equally to both observers.

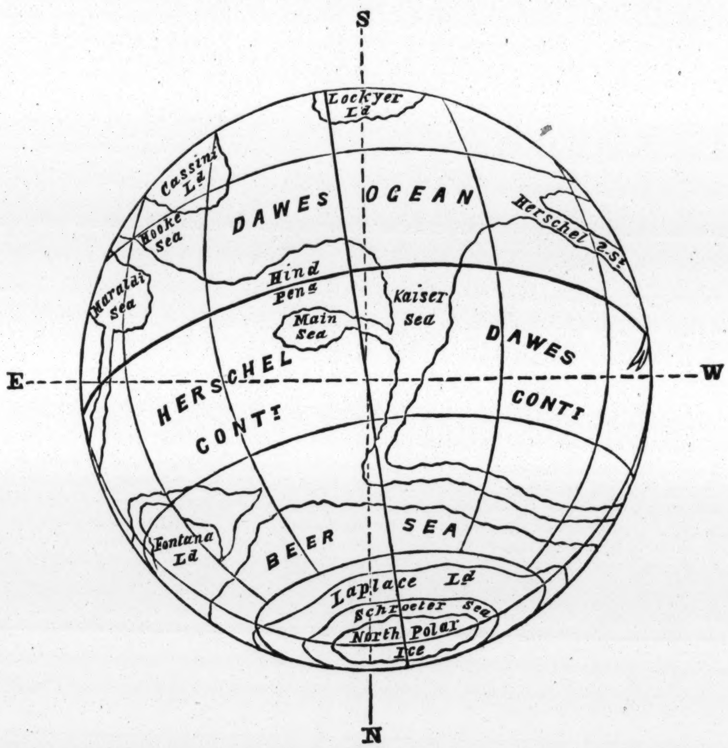
By means of the new method it will be possible to chart the prominences from day to day and from hour to hour. Already we have learned two important facts respecting them. In the first place, we now know that they are continually changing in figure and arrangement, as was indeed to be expected from their flame-like character. Secondly, we now know that sodium is not an element in the structure of the protuberances. The spectrum of the sun being brought into direct contact with that of a prominence by the new method of observation, no measure is required for the determination of the position of the bright lines forming the prominence spectrum. The orange line which had been supposed by Lieut. Herschel and others to be the double line of the metal sodium, is now found not to agree in position with the dark line D of the solar spectrum, which is known to be due to absorption by sodium-vapour in the sun's atmosphere. Thus the vapour to which the bright orange line in the prominence spectrum is due cannot possibly be that of sodium. It seems clear, however, that the red and green lines are due to burning hydrogen.

We mentioned that, according to received views respecting the meteoric zone to which the November shooting-stars are due, there was but little prospect of the display being seen in England this year. Our views were subsequently confirmed by a letter addressed to 'The Times' by Mr. Hind, the superintendent of the 'Nautical Almanac,' in which he stated that the probable hour of the earth's passage through the zone would be six o'clock in the afternoon of November 13th, at which hour England would be on the sheltered side of the earth. However, the anticipations of astronomers were not fulfilled by the result. The display was well seen in several parts of England and Europe on the morning of the 14th of November. The only explanation of this peculiarity which seems at first sight available is that the meteoric zone had been swayed from its mean position (as respects this part of its length) by the attractions of the planets, and that thus the earth passed through it several hours later than had been expected. The news that the display has been seen well in America points also to the widening out of the zone.

The planet Mars will be in opposition on February 13th next, and for several weeks before and after that date he will be very favourably situated for observation. He will not, indeed, be so near to the earth as at many oppositions; in fact, he will be so close to his aphelion that he will be almost as unfavourably situated, as respects distance, as he possibly can be when in opposition. But on this very account he should be studied all the more carefully, as the portion of his globe which will be turned towards the earth is that which has been least studied, owing to the fact that it is never presented towards us except when Mars is in or near aphelion.

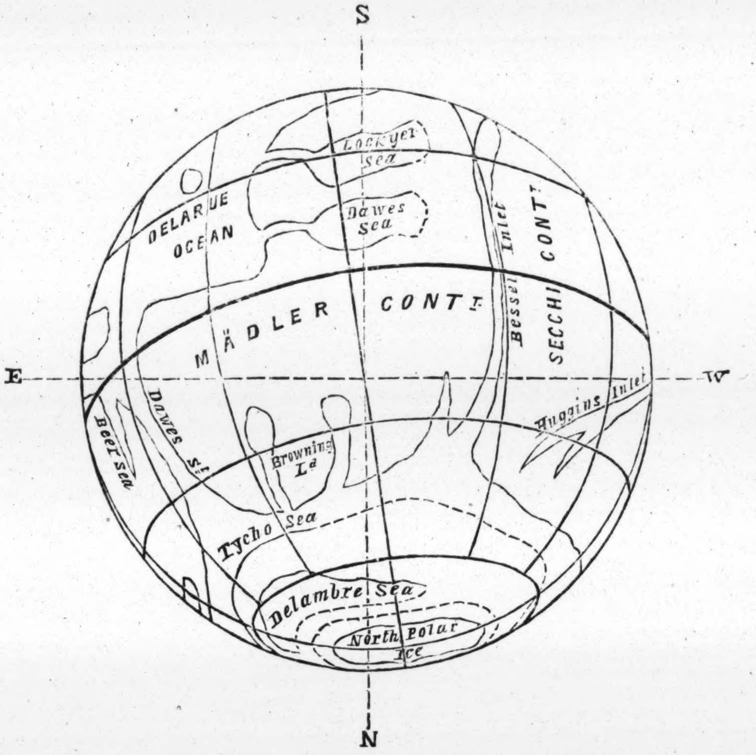
In Figs. 1 and 2 the presentation of Mars at the approaching opposition is exhibited. The features are those presented in Proctor's charts, which are derived from a series of drawings by the late Mr. Dawes. Many of the features of the northern hemisphere require, however, to be carefully re-observed, since Mr. Dawes made his observations on this hemisphere with an instrument considerably inferior in power to that which he made use of in observing the southern hemisphere; and (as we have noticed) the northern hemisphere is only turned towards us when Mars is in aphelion. We must also remark that it is not merely the question of presentation which has to be considered. When Mars is presented towards us as shown in Figs. 1 and 2, he is also presented in almost exactly the same way towards the sun. Hence it follows that the northern hemisphere is enjoying the martial summer; and accordingly the martial skies are clearer over that hemisphere, and its features are proportionately more distinct. This is no mere speculation respecting the condition of the martial globe, but corresponds exactly with the

FIG. 1.



peculiarities which have been observed by all our leading telescopists.

Fig. 2.



Mars will have a high northern declination during the next four months, and therefore his definition will be good, in ordinary observing weather, when he is on or near the meridian.

Many observers have been successful in obtaining good views of the recent transit of Mercury. Amongst the observations, the most important are those which were made at Greenwich under the superintendence of the Astronomer Royal. He was enabled to employ no less than six telescopes, including the great equatorial, in observing the transit. In every instance the planet was observed either to assume a balloon shape, or to throw out a ligament, as it approached the edge of the sun's disc. Mr. Airy remarks that he had always been disposed to refer the peculiarities seen during the transits of Venus in 1761 and 1769 to the imperfections of the telescopes employed, but having now seen what has happened with telescopes unimpeachable in character, he thinks differently. He ascribes the peculiarities to the effects of irradiation. With the great equatorial, Mr. Stone could see no trace of any spot upon the disc of Mercury. He could see a ring of light round the planet.

Mr. Huggins observed the transit with his 8-inch equatorial, using the full aperture. The weather was on the whole favourable, as the bright granules over the sun's surface could be well seen. The planet appeared as a round, evenly-defined spot, with an annulus of light one-third of its apparent diameter, having a well-defined boundary, and appearing rather brighter than the sun's disc. Nearly in the centre of the planet's disc there was a spot of light. As the ring was seen when the darkest part of the neutral tint sliding wedge was made use of, and in fact rather better then than when the shade employed was lighter, Mr. Huggins considers that the ring cannot be looked upon as a mere optical effect of contrast. An atmosphere round Mercury hardly seems to be a sufficient explanation of the ring of light. As for the point of light on the disc, that is an old difficulty. Probably the fact that Stone could see no such point with the great Greenwich equatorial, will lead to the opinion that the appearance is connected in some way with the quality of the telescope employed.

At a recent meeting of the Royal Astronomical Society, the Astronomer Royal stated that he had obtained from Dr. Miller, of Cambridge, evidence confirmatory of the connection which has been supposed to exist between comets and meteors. It will be remembered that Mr. Huggins's analysis of Comet II., 1868, showed that that object consisted of carbon in the state of incandescent gas. It appears that there are four meteoric stones, at least, which contain carbon. Of these, one fell in the south of France, one at the Cape of Good Hope, one at Debreczin, in Hungary, and the fourth at Orgeuil, in France.

The number of discovered asteroids has now reached 106.

There will be an eclipse of the moon, visible in England, on the morning of January 28th. First contact with the penumbra will take place (at Greenwich) at 11 h. 18·2 m. P.M., January 27; first contact with the shadow at 0 h. 29·2 m. A.M., January 28; the middle of the eclipse at 1 h. 38·2 m.; and last contact with the penumbra at 15 h. 58·2 m. Somewhat less than one half (more exactly 0·450) of the moon's diameter will be eclipsed. The first contact with the shadow will occur at 50° from the northernmost point of the moon's limb towards the east; last contact at 31° towards the west.

PROCEEDINGS OF THE ROYAL ASTRONOMICAL SOCIETY.

Dr. O. Pihl has laid before the Astronomical Society the results of a micrometric examination of the stellar cluster in Perseus. He has been prosecuting this examination since the year 1860, with a view to obtain, within comparatively small probable errors, a mensuration of all the more conspicuous stars, sufficiently exact to serve as a basis for investigating at some remote date the mechanism of the system. The instrument which he has made use of in these researches is a refractor, 3¼ inches in aperture, equatorially mounted, by Lohmeyer, of Hamburg. We have not space to describe in full the various arrangements adopted by Dr. Pihl to secure accuracy. Our readers will probably be more interested in learning that, as far as the researches have yet gone, there would seem to be indications of movements having taken place since the epoch of Bessel's measurements. The mean declination of seven stars examined by Bessel is 4″ 27 south of the mean declination as now observed. "Is it probable," says Dr. Pihl, "that this difference is owing to errors in observation or reduction, and to no physical change?" This is a question which cannot be answered until the course of time enables astronomers to obtain some satisfactory evidence respecting any process of change which may be going on.

A remarkably interesting paper is supplied by Mr. Stone, on the subject of the observations made upon the transit of Venus which took place in 1769. Our readers are doubtless aware that the estimate of the sun's distance, which has so long found a place in our treatises of astronomy, was founded upon those observations. When other methods of determining the sun's distance had led to results differing by three or four millions of miles from the value hitherto received, astronomers were somewhat at a loss to understand how it was that so faulty a value should have resulted from a series of observations so elaborate, and apparently so successful, as those which were made upon the transit of 1769. It will be remembered, that the calculation of the sun's distance had been managed by Encke, and there seemed every reason for supposing that he had spared no pains to treat the observations which came under his hands in the most careful and satisfactory manner. An attempt was made by Powalky to show that the observations of the transit could be made to agree with modern determinations of the sun's distance. But, according to the opinion of the best mathematicians, Powalky allowed himself far too great freedom in selecting the materials he made use of. Professor Newcombe, of America, had been more successful in representing the observations of 1769. Still, however, there was considerable discordance.

It appeared to Mr. Stone that a new discussion of the observations of 1769, if made with due care, would necessarily lead to a clearer view of the sources of systematic error, or wrong interpretation which might be feared and ought to be guarded against, in the observations proposed to be made of the transits of 1874 and 1882. In the course of his investigations he was led to the detection of several grave and fundamental errors, which had previously been made in the discussion of the observations of 1769, and to a value of the solar parallax, entitled to be received with confidence.

The great difficulty lies in the fact that at the moment of true internal contact Venus does not present the appearance of a circular disc, but is apparently pear-shaped. This phenomenon is due to the effects of irradiation, by which the sun's apparent diameter is increased, while that of the planet is diminished. But the great difficulty in judging of the observations made in 1769 has lain in the necessity of following some law or other as to the choice of what shall be held to be the true moment of internal contact. The error which Stone has discovered in Professor Encke's mode of treatment consists in the fact that the latter did not apply a uniform law to the observations which came under his notice; that, in fact, in one or two instances, he misinterpreted the words of the observers. "I consider," says Mr. Stone, "that by simply interpreting strictly the language employed by the observers, I have been led to a solution which satisfies the whole of the ten observations, and gives, at the same time, from the equations of condition, a satisfactory result for the difference between the time of internal contact and the breaking of the black drop." The value of the solar parallax deduced from the new treatment of the observations is 8″ 91, a value which agrees in the most satisfactory manner with that which had been obtained as the mean of other methods of estimating the parallax.

We must remark, however, that Professor Newcombe considers Mr. Stone's interpretation of the observations made in 1769 as untenable.

Mr. J. Tebbutt, jun., supplies a series of observations made by him upon the star η Argûs. He compared this singular variable with neighbouring stars. It appears from these observations, that η Argûs has not exceeded the sixth magnitude during the past two years. Thus we are compelled to reject the theory of Professor Wolf, who assigned a law of variation according to which the epoch of minimum brilliancy should have occurred in 1861, and the magnitude of the star should have been 3·6. Certainly η Argus is the most remarkable star in the whole heavens. A quarter of a century ago, it outshone the brilliant Canopus, and rivalled Sirius itself in splendour; now it can only just be detected with the naked eye on a very clear night.

Two biennial meetings have been held of the Astronomische Gesellschaft, under the presidency of Professor Argelander, and the heads of the subjects discussed appear among the notices of the Astronomical Society. Amongst these, we may notice the following:—It has been suggested that the older observations of the Periodic Comets should be re-examined. Four points have been specified—the new determination of the places of the stars of comparison, the calculation of the auxiliary quantities with the now-received values of the constants for the times of the appearance of the comets, the calculation of solar ephemerides for these times, and lastly, the publication of the originals of the older comet observations. It appears that the calculations for the comets of

Encke, Faye, Brorsen, D'Arrest, and Tuttle, are being proceeded with; but a list of thirty-one comets, from 1830 to 1867, remains for further discussion. A wish was expressed that astronomers who are occuping themselves with any particular comets, would put themselves in communication with the Society. A programme was received for the observation of all stars, down to the ninth magnitude, between circles of declination 2° S. and 80° N. The observatories which had offered to take part in the work were Berlin, Bonn, Helsingfors, Leipzig, Mannheim, and Leyden.

4. BOTANY, VEGETABLE MORPHOLOGY, AND PHYSIOLOGY.

The Fertilization of the Scarlet-runner and Blue Lobelia.—Mr. T. H. Farrer, a gentleman previously unknown to fame, but evidently a careful observer of nature, set himself to work upon the question as to whether other plants besides those described by Mr. Darwin (Orchids, Primula, Linum, and Lythrum), might not have a structure which provided for the fertilization of one's ovary by the pollen of another flower. As Mr. Farrer observes:—"To an amateur, dismayed by the difficulties of botanical classification, perplexed by his own incapacity for microscopical dissection, and disgusted by the mere cataloguing of species, Mr. Darwin's suggestion that the true account of the structure and functions of flowers is frequently to be found in their capacity for cross-fertilization with the pollen of other flowers, is a ray of light which opens out an endless field of interesting observation." We wish there were more such amateurs. We cannot give Mr. Farrer's observations, which are very detailed, and published in the 'Annals of Natural History' for October. He shows that there is such an arrangement of the parts of the flower of the Scarlet-runner, that a bee, alighting and searching for honey, necessarily shakes any pollen off his proboscis on to the stigma, whilst, by another device, his proboscis gets covered with the pollen of this flower as he withdraws it, and is ready to fertilize another. In Lobelia, Mr. Farrer describes a very remarkable disposition of parts, which act so that when a bee visits a Lobelia flower, pollen is ejected, in small quantities at a time, on the exact spot on his back on which it should be placed in order that it may be carried to the stigma of another flower, the stigma in these flowers also being so arranged that, at the very next flower visited by the bee, the stigma sweeps off the previously acquired pollen.

The Double Cocoa-nut.—Dr. E. Perceval Wright, Professor of Zoology in Trinity College, Dublin, visited, in 1867, the Seychelles

Islands: he stayed there some time, making valuable observations on botanical and zoological subjects. One matter which very greatly occupied his attention was the condition and growth of the forests of *Lodoicea*—the celebrated Double Cocoa-nut of these islands. Before the Seychelles were discovered, the nuts used to be picked up floating on the seas, and were considered rarities of extraordinary value: at length their home was discovered, and now their whole history is known, excepting how or whence they came to the Seychelles. There is no palm like them, that can be possibly pointed to as an ally, or as a possible descendant from a common ancestor, unless we pitch the date of that ancestor far back in time. And this is what we must do; we must suppose that for ages the Lodoicea has grown on the Seychelles, and has become so modified in that great space of time, that it is now quite unlike any other palms in many important particulars. It was feared, some time since, that the Double Cocoa-nut was about to become extinct, like most other living things formed in the microcosm of an ocean-island, when exposed suddenly, through man's agency, to the influence, more or less, of the macrocosm; but this fear was set at rest, and Dr. Wright tells of several large forests containing thousands of these trees, many from 100 to 150 feet in height. Dr. Wright finds that the growth of the stem depends very much on the soil in which it grows. Of a number planted in 1812 on Silhouette, some flowered and bore fruit in 1851, being then 26 feet high and 4 feet in diameter at the base; whilst others which, though close by, were in very poor soil indeed, had no stems at all, and have borne neither fruit nor flowers to this day. It is unsafe, Dr. Wright thinks, to judge of the rate of growth of trees by *planted* specimens.

The "Haofash" of Cochin China.—The 'Moniteur' gives an interesting account of a tree called Haofash, which grows on the mountains of Baria, in French Cochin China. It grows wild in the forests, hidden among Lianas and other creepers, which render the wooded mountains of that country almost impervious to the traveller. Nor do the inhabitants, generally speaking, know the botanical or medicinal properties of this plant, so that it remains a secret in the hands of the bonzes and physicians. MM. Condamine and Blanchard, two French travellers, have at length succeeded, after much fruitless search, in finding this tree—having bribed a bonze to disclose it to them. The bark is stripped from the tree in its third year, when it is about 24 feet in height. The operation is performed in June, when the tree has neither blossoms nor fruit; it is hewn down, and then denuded of its bark methodically in slices about 2 feet long and 3 or 4 inches broad. The bark of the Haofash is outwardly of an ash-gray colour, and inwardly brown; it has a strong aromatic smell and a slightly bitter taste. When chewed it reddens the saliva; it is a powerful styptic; it is administered by the physicians of the country in cases of colic, diarrhœa, and dysentery.

The Ordeal Poison-nut of Madagascar.—Dr. Bennett, of Sydney, writes an account of this tree in the 'Journal of Botany.' Specimens of it have been naturalized in New South Wales, and in the Botanical Gardens at Sydney there is a very fine tree of it, which somehow or other obtains a mysterious sort of respect from the visitors to the gardens, who, although they do not hesitate to gather from other flowers and shrubs, stand in awe of the Ordeal-tree. The flowers are very fragrant, of a crimson colour, and appear in November and December. The plant belongs to the natural order *Apocynaceæ* and its native name is *Tanghin*—whence *Tanghinia*. The fruit is of the size of a hen's egg, containing a hard stone or nut, the kernel of which is white, of a bitter taste, and has remarkable poisonous properties. The poison of the ordeal-nut acts *directly* upon the heart and muscles. When used by the natives as a detector of crime, the kernel is pounded and administered to the supposed criminal. Frequently sickness is caused, and the accused then escapes. If not, the poison is rapidly absorbed, and death ensues. A difference of colour is said to exist between those kernels which produce only vomiting and those which produce death; and the friends of an accused person will stand by and object to certain nuts being used, The officers are said to administer these two varieties in a partial way, but it is not very certain that they can really discriminate between the virulent and less active kernels. Dr. Bennett suggests that there may be two species of *Tanghinia* existing in Madagascar, differing in the intensity of their poisonous power. The milky juice of the *T. Manghas* is said to be used as a purgative, and according to Rumphius the natives boil and eat the leaves mixed with other pot-herbs, which thus act as a gentle laxative. The bark is also used in Java and Amboyna as a familiar cathartic, the action of which is said to be very similar to that of senna. Manghas is the name given to the tree in its native country.

New British Plant.—Potentilla Norvegica has been discovered by Mr. G. S. Gibson, in Wicken Fen, near Upware, in Cambridgeshire. It was found growing on the side of one of the marsh ditches, and was carefully identified by comparison with the specimens in the herbarium of Linné and in that at Kew. The plant is inconspicuous, and likely to be passed over, except when in flower. Its geographical distribution renders it unlikely to be found native in the southern parts of England, and Mr. Gibson cannot account for its introduction in so rough a spot, and it is not a plant that he has ever seen in cultivation. We would suggest the possibility of the barges passing on the Cam, which is little better than a canal, as the means of introducing the plant. There are superphosphate works at Cambridge, and possibly certain boat-loads of foreign phosphate may have been brought by Upware thither.

New British Seaweed.—Mrs. Alfred Gatty has found in Cardigan Bay, and Dr. J. E. Gray has described in the Ann. and Mag. Nat. Hist. *Elachista stellaris.*—There are eight other British species of *Elachista*, which Dr. Gray arranges in three groups. Mrs. Gatty also found *Gigartina pistillata* in fruit in Blackpool Bay. The late Dr. Harvey saw the specimen, and recorded it in the herbarium of Trinity College, Dublin.

Palu.—Some time ago a very small quantity of a fine silky substance was brought to England from California under the above name, and it was used as an object for the microscope, on account of its beautiful structure. Mr. Bingham, in his very interesting paper "On the Volcanic Phenomena of the Hawaiian Islands," says,—"*Palu* is the silky covering of the opening fronds of several species of tree-ferns, and is exported in large quantities to California, for beds,* &c." The trade is so extensive that "corduroy roads" are made to the station where it is collected, and whole districts are leased for the "Palu business," and there is a large number of "Palu pickers." The *Palu* is collected at Kelanéa, which is the most tropical region in Hawaii. The tree-ferns have stems 15 feet high to the base of the frond, and 8 or 12 inches in diameter.

Plants without Roots.—The French Academy has received a paper from M. Duchartre on certain plants which vegetate without roots. In South America people will suspend such plants from a balcony by a thread, without their being in contact with anything else, and yet they will grow and blossom in this strange position. In our hothouses we see them, simply stuck upon a piece of wood or cork, thrive beautifully without any roots. The question therefore is, How do they live? M. Duchartre, to discover the secret, has instituted a series of experiments on a plant of this family—the *Tillandsia dianthoidea.* Two tolerably equal sprigs of it, without a vestige of roots, were tied separately to two slices of dry cork from the same piece. They were then freely suspended in the air, and weighed from time to time. One of these plants, A, never got any water at all; the cork of the other, B, on the contrary, was moistened every second or third day. After the experiment had been continued 103 days, A had lost one-third of its weight, but had nevertheless produced blossoms and a small root; B, on the other hand, was extremely vigorous, and had increased one-eighth in weight. M. Duchartre thence concludes that these plants require water, but do not absorb the moisture of the atmosphere.

Reproduction of the Diatomaceæ.—In the last number of the 'Quarterly Journal of Microscopical Science' Count Castracane describes some important observations, which lead him to believe that Diatomaceæ reproduce by means of germs. He describes what he considers as zoospores having cilia and containing diatoms. The young germs do not present the brown endo-chrome, but are of a bluish-green colour. Count Castracane's observations are given in detail and are of great importance, since we may hope that they will lead to further observations in this country and elsewhere. It is strange that whilst there are hundreds of Diatomaniacs, the questions of the physiology and anatomy of these organisms remain so long doubtful. Max Schultze has settled the locomotive question, but there remain others unanswered. We believe that most Diatom-men would scorn to look at a frustule that had not been boiled in nitric acid, and hence the incompatibility between the number of students (*sic!*) and the great ignorance prevailing as to Diatomaceæ.

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* P. 426.

Fungological Gastronomy.—The Woolhope Naturalists' Field Club recently devoted a day to investigating the Fungi of their district. The party met at Hereford, and under the direction of Mr. Edwin Lees, F.L.S., and of Mr. W. G. Smith, they proceeded to collect a vast variety of both poisonous and edible mushrooms, from Holme Lacy Park and the neighbouring hills. It was to the edible forms, however, that the members turned their attention principally, as they were to be cooked and eaten at dinner after the excursion. With the fish and the soup came the first novelty in the form of "Oreades ketchup." It was good with either, and was pronounced by all present a brilliant success. A dish of beefsteak, animal and vegetable, was served, deliciously mingled to the advantage of both, and at the same time a dish of the *Fistulina hepatica*, the "Liver fungus," or "vegetable beefsteak," by itself was handed round. The slices were cut from a large specimen, gathered in the morning. The next Agaric to appear was *Hydnum repandum*, the "spiked mushroom," from Haywood forest. It was stewed and broiled, and those members of the Club who had resolved themselves into a committee of critical taste, and to whom therefore all dishes were immediately brought fresh and hot, quickly separated the Agarics from their gravy, and found them excellent, and particularly the broiled ones, not at all unlike *oysters*, to which they have been compared. Then followed the Parasol Agaric (*Agaricus procerus*), and after this, the Fairy-ring Champignon (*Marasmius oreades*), broiled on toast, after the admirable receipt of Soyer. A dish of *Agaricus prunulus*, or *Orcella*, was also served, simply stewed, and was declared to be "delicious." After dinner our convivial fungologists listened to four instructive communications on various matters relating to Fungi: their spores—those that are British, why they ought not to be eaten, and those belonging to Fairy-rings.

Flora of Middlesex.—The work having this title, by Dr. Henry

Trimen, of St. Mary's Hospital, London, and by Professor Thiselton Dyer, of Cirencester College, will be speedily sent to press, and may be expected to be published by Mr. Hardwicke early this year. The work will not be a mere record of the occurrence of species, but much pains has been given to tracing out the origin of the Flora as far as possible, and (what is interesting from an antiquarian point of view) the former extension of species over parts of Middlesex now become London. This sort of observation has, too, a great value in connection with the causes of the extinction of species.

Flora of Bucks.—A second 'List of Buckinghamshire Plants,' including the additions which have been made to the known Flora of the county during the past year, will shortly be published. It is requested that anyone possessing information on the subject in his possession will forward the same to James Britten, High Wycombe.

Chair of Botany at Dublin.—Professor Dickson having accepted the Chair of Botany at Glasgow University, the lectureship in the College of Science and the professorship in Trinity College, Dublin, became vacant. Dr. Perceval Wright, Professor of Zoology in Trinity College, was the natural successor of his late colleague to the more valuable post. Dr. Wright is well known as a teacher of botany, and an original explorer in botanical science as in zoology. For some reason, however, Dr. Wyville Thompson, of the Queen's College, Belfast, is selected for the Government appointment, and therefore for the University chair also.

University of Vienna.—The celebrated botanist, Dr. Karsten, of Berlin, has been elected to the Chair of Vegetable Physiology at Vienna, vacated by the retirement from office of Dr. F. Unger.

5. CHEMISTRY.

(*Including the Proceedings of the Chemical Society.*)

The preparation of oxygen has already been alluded to in these Chronicles on more than one occasion, and several processes have been described by which this gas may be obtained indirectly from the atmosphere. Closely allied to the preparation of oxygen on a large scale is that of chlorine, and it has recently been announced that a Belgian chemist has devised a new process for generating this gas. He first forms sulphate of sesquioxide of iron, by the direct combination of this oxide with sulphuric acid, and then mixes the sulphate obtained with three equivalents of chloride of sodium or other convenient chloride. Upon heating the mixture in dry air, the chloride of sodium is said to yield all its chlorine.

Mr. Mallet has continued his experiments on the production of oxygen, and has now modified his process in such a manner that he can also obtain chlorine on a large scale. As certain novel or but slightly known reactions have brought this process into some note, a few explanations are necessary. The fixation of atmospheric oxygen upon protochloride of copper allows two results to ensue; either the disengagement of oxygen, supposing the desired end be to collect that gas, or the decomposition of chlorhydric acid and liberation of chlorine, should the production of that body be desired. The absorption of oxygen by protochloride of copper is spontaneous, and takes place at the ordinary temperature in a few hours, provided the air be sufficiently moist, and especially if the surfaces be renewed. If the temperature be raised the absorption is more rapid, and this is the most important part of the question, for by raising the temperature to between 100° and 200° C., or even higher, in the presence of steam, absorption may be regarded as almost instantaneous.

If upon protochloride of copper, heated to 100° or 200°, commercial chlorhydric acid be slowly dropped, steam alone will be disengaged, and supposing the addition of acid to be slow enough, and the access of air and renewal of surface sufficient, the odour of chlorhydric acid will be scarcely perceptible, and the whole protochloride will transform into anhydrous bichloride, which, when heated in a close vessel, instantly disengages chlorine. The simultaneous absorption of oxygen and chlorhydric acid is an important and interesting fact, because the extraction of the chlorine from the acid takes place in this case by means of the atmospheric air, and in an absolutely direct manner. With gaseous chlorhydric acid the action is the same, in fact better, provided the acid gas contain, as is always the case, a certain quantity of steam, and that the accession of air be sufficient. The presence of water is necessary to the absorption of oxygen by protochloride of copper. Oxidation and chlorination take place very quickly at high temperatures, but the great advantage is that they yield dry products, which is very convenient, inasmuch as steam is frequently a source of inconvenience and alteration of apparatus. From a manufacturing point of view, it may be considered that 100 kilogrammes of protochloride of copper, mingled with sufficient inert matter to facilitate manipulation, will produce practically from three to three-and-a-half cubic metres of oxygen, or from six to seven cubic metres of chlorine. As four or five operations at least may be performed in twenty-four hours, it is plain that 100 kilogrammes of substance will produce from fifteen to eighteen cubic metres of oxygen, or from 200 to 300 kilogrammes of chloride of lime, in twenty-four hours.

The price of the raw material does not exceed one franc the kilogramme, and the loss is ascertained by experience to be always very small; this is easily understood, as the substance does not leave the retort, but undergoes all the processes within it.

Professor Stas gives the following as the best method of preparing sulphurous acid, a gas which is largely used as a reducing agent and disinfectant. A current of sulphurous acid is obtained by attacking, by means of copper, pure sulphuric acid, diluted with from one-half to two-fifths its volume of water. To make sure of the purity of the sulphurous acid, pass the current, at first through water contained in a large washing flask, then through two Woulfe's bottles completely filled with pumice-stone broken into small fragments and moistened. The moistened pumice-stone, previous to its introduction into the bottles, is twice calcined with sulphuric acid, so as to free it from the chlorides and fluorides which it often contains.

Professor Wöhler, to whom we owe the first published account of aluminium and magnesium, has lately published the following facts concerning the metal cerium. The colour of the metal is intermediate between the colour of iron and that of lead. The metal is lustrous when polished; it is malleable. Its density is about 5·5 at 12°. Exposed to the air it loses its lustre, and becomes slightly blue. It feebly decomposes water at 100°. Hydrochloric acid dissolves it with energy; concentrated nitric acid converts it into clear brown oxide; the dilute acid dissolves it. By evaporation, a white salt is obtained, which leaves, after calcination, a brown oxide, insoluble in nitric acid and in dilute sulphuric acid. Concentrated sulphuric acid slowly dissolves this oxide, forming a yellow solution which shows the reactions of ceric salts. Hydrochloric acid dissolves this oxide with disengagement of chlorine, forming a colourless solution. When a globule of cerium is heated by the blow-pipe to dull redness, the metal inflames and burns vividly, forming brown oxide; but upon submitting a globule suddenly to a very high temperature, it burns with explosion, sending out bluish sparks. Cerium powder can inflame below 100°.

The rapid and accurate estimation of the amount of sulphur contained in pyrites is a matter of importance to that very large section of industrial chemists who are interested in the manufacture of vitriol. Professor Wöhler has discovered that hypochlorous acid may be used to transform the sulphur of pyrites into sulphuric acid, which is then estimated by baryta. He directs to finely pulverize the mineral and suspend it in water, through which a current of gaseous hypochlorous acid, or better still hypochloric acid, is passed; this entirely dissolves the pyrites. Hypochlorous acid is prepared by heating a milk of carbonate of lime, through which a current of chlorine is passed to saturation. Hypochloric acid is obtained by heating in a water-bath a tube supplied with a cork and delivery tube, and containing a mixture of 9 eqs. of oxalic acid and 1 eq. of chlorate of potash.

Professor Wöhler has also published a good method of separating phosphoric acid from bases. It consists in dissolving the substance to be analyzed in a small quantity of nitric acid, and adding to the solution, first nitrate of silver, then carbonate of silver, and well shaking. All the phosphoric acid then combines with the oxide of silver and is precipitated, whilst the bases remain in solution and may be freed from the excess of silver by means of hydrochloric acid.

The element phosphorus has been applied by W. Schmid as a re-agent for metals. When a solution of crystallized phosphorus in bisulphide of carbon is shaken with water, a perfectly white precipitate is formed. The presence of traces of metals causes the precipitate to assume various colours. Thus solutions of copper are precipitated brown; those of silver, black; of mercury (oxide), yellowish brown; of gold, violet. The filtrates contain generally sub-oxides.

In an examination into the action of iodine on the hydrogen compounds of antimony and arsenic, M. Husson has discovered a reaction which may furnish a useful application in toxicological researches. He finds that antimoniuretted hydrogen and arseniuretted hydrogen form iodide of antimony and iodide of arsenic when the two gases are made to pass over iodine. A tube containing a small piece of iodine being joined to the Marsh's apparatus, gentle heat is applied to volatilize the iodine, which, upon condensation, lines the tube. Then, while the tube is still slightly warm, the gas is allowed to pass. If this contains arseniuretted hydrogen, the iodine will be bordered by a yellow line formed of little straw-like masses, having much analogy with iodoform; the iodine disappears completely. With antimoniuretted hydrogen the reaction is less manifest; all the iodine collects, forming a deep ring, orange-tinted on the one side, and brown on the other. But the action of heat enables these two iodides to be distinguished thus:—The yellow iodide of arsenic is transformed, one part into red iodide with disengagement of iodine, the other volatilizes in the state of yellow vapours, which are received on unsized paper; the same phenomenon is produced under the influence of an excess of arseniuretted hydrogen, whence M. Husson is inclined to conclude that a periodide of arsenic is first produced. Iodide of antimony, on the other hand, evolves red vapours, and leaves a little reduced antimony.

Dr. T. Werner recommends the following process to detect the presence of atmospheric air in coal gas:—Ten parts by weight of anhydrous sulphate of protoxide of manganese are put into a two-necked bottle, and then dissolved in twenty parts of warm water. To this mixture is immediately added a solution of ten parts by weight of tartrate of potash and soda (Rochelle salt), dissolved in sixty parts of water; the thorough mixing of the fluids is promoted by well shaking the bottle; after this there is added a quantity of a solution of caustic potash sufficient to render the fluid quite clear; immediately after this the corks, perforated and fitted with very tightly fitting glass tubes, are placed in the necks of the bottle, which should be entirely filled with the mixed fluid just alluded to. One of the glass tubes—the inlet tube for the gas to be tested—should just dip a little under the upper level of the fluid; the outlet tube, on the other hand, should only reach halfway through the perforation of the cork. A very slow current of gas is now made to pass through the fluid, and kept going for at least 15 minutes, and at-most one full hour. In case the gas is quite free from atmospheric air, the fluid in the bottle will remain quite clear; if even traces of air are present, a faint coloration of the liquid will soon become apparent; with a larger proportion of air present in the gas the fluid will soon be rendered, first light brown coloured, and afterwards intensely black. Since these changes of colour are due to the oxidation of the salt of manganese, it is evident that every care must be taken to avoid the presence or access of accidental air; the fluid in the bottle should reach the cork. It is best to cool the bottle during the experiment with ice, if at hand, otherwise with very cold water; the current of gas must be slow.

M. Monnier has discovered a process for refining sugar, which is likely to prove of considerable commercial value. When a current of anhydrous sulphurous acid is passed into a chamber containing coarse sugar, a bleaching action ensues, and three-fourths of the colouring matter of the sugar is destroyed, while no alteration whatever is suffered by the sugar itself. After this treatment, the sugar is strongly impregnated with sulphurous acid, but the presence of this body does not interfere with subsequent operations. About four parts of sulphur are required for every 1000 of sugar, but when the process is in regular operation, the amount of sulphur can be sensibly diminished. The sulphurous acid gas is obtained by burning sulphur in a small furnace adjoining the chamber. When the operation is terminated, the sugar is dissolved in water, and the sulphurous acid neutralized by lime previously converted into sucrate of lime. M. Monnier feared that, in practice, the anhydrous sulphurous acid might modify the sugar, and convert a portion into grape sugar. He has, however, convinced himself that no action of this kind takes place; the proportion of uncrystallizable sugar, found by analysis, after treatment by the process, being always exactly equal to the original amount. In all the experiments the sugar remained exposed to the bleaching action for forty-eight hours. This process gives excellent results with the strongly coloured West Indian sugars; with samples less coloured the action is not so marked. In the first case, two-thirds or three-fourths of the colouring matter is completely removed.

M. Dumesnil has devised a new process for preserving wine, which is of considerable interest. The cask of wine, uncorked, is placed under an iron bell and the air exhausted; two hours' work is necessary before the noise occasioned by the exit of the air ceases. A vacuum being created, the gases contained in the wine are released from atmospheric pressure and expand sufficiently to break the cells of vegetable fibrin enclosing them, and escape. The withdrawal of 30 or 40 litres of gas occasions no sensible decrease of liquid. M. Dumesnil gives an example of the practical value of his process. He allowed the wines of 1865 to ferment till March, 1866, so as to allow of the conversion of all the sugar and extractive matter into alcohol. At this period he substituted for the usual operations the treatment by the vacuum; fermentation ceased entirely. The wines thus treated arrived at their destination in good condition; with other samples treated in the usual way the result was very different. Notwithstanding four rackings, and possibly four clarifications, the wines have continued to ferment during the whole of the year 1866 and also the commencement of 1867, and they probably still contain gases which will affect them more slowly. M. Dumesnil mentions that his wines of 1867, treated in last March by the vacuum, yielded twice as much gas as those of 1865.

A memoir presented to the Academy comprises the first portion of the results of M. Kolbe on the bleaching of flax. The research has led to the establishment of the following facts:—The gummy substance which adheres to the fibres of flax is nothing else than pectose. The soaking or steeping of the fibre appears to have for its object the determination of the pectic fermentation, and the pectic acid which results remains fixed on the flax, either mechanically or, in part, in the form of pectate of ammonia. The caustic alkalies in the cold form gelatinous pectates, which preserve the fibre from being completely attacked. Pectic acid being weak, the alkaline carbonates have in the cold only a feeble action upon the fibre. Ebullition, on the contrary, transforms pectic acid into an energetic acid—metapectic acid; the carbonates are then strongly attacked, and their employment becomes as efficacious as that of caustic alkalies. The carbonate of soda, even in large quantity, is not a cause of the weakening of the fibre, which loses more strength from the employment of caustic soda, especially when the lye is concentrated. The employment of lime, even in the cold, weakens the fibre considerably, but the chief cause of the destruction of the solidity of the fibre is too prolonged digestion, particularly with caustic soda. M. Kolbe says, that after having proved the existence of pectose in the unsteeped flax, and of pectic acid in the same flax after steeping, it is to be hoped that the attention of chemists will be drawn to the pectic fermentation, well known, doubtless, as a scientific fact, but of which no one suspected an industrial application of so high importance.

The value of carbolic acid as a cure for the bites of venomous snakes has been made public by Dr. J. W. Hood, B.Sc., of Melbourne. He writes: "I have long entertained the opinion that carbolic acid, taken internally and used as a caustic to the wound, would be found to be beneficial, and, perhaps, a specific cure. That I am right, to a certain extent, is proved by the fact that a friend of mine, a medical man living at Warrnambool, Dr. Boyd, successfully treated two cases of snake-bite with carbolic acid. I am not aware of more particulars than that the first case was a young lad bitten by a tiger-snake, the most venomous these colonies produce, and Dr. Boyd—six hours after the boy was bitten—administered ten drops of pure acid in brandy and water, every few minutes. The effect was magical—from a pallid countenance, slow pulse, and semi-comatose condition, the patient rallied to a bright expression, ruddy glow, and quick pulse, and the recovery, though slow, was continuous and certain."

In a short communication to the 'Centralblatt,' Drs. Bergmann and Schmiedeberg describe a crystalline substance, to which they have applied the name "sulphate of sepsin," obtained from putrefying materials, and which they believe represents the proper poison of organic substances undergoing this kind of fermentation. It is obtained by diffusion through parchment paper, precipitation with corrosive sublimate from an alkaline solution, removal of the mercury by silver, of silver by sulphuretted hydrogen, evaporation, and purification of the residue. Large, well-defined, acicular needles are thus obtained, which are deliquescent in the air, and when exposed to heat, melt and carbonize. They possess a powerfully poisonous action. A solution containing scarcely more than one-hundredth of a gramme was injected into the veins of two dogs. Vomiting was immediately induced, and after a short time diarrhœa, which in the course of an hour became bloody. After nine hours the animals were killed, and on examination their stomachs and large intestines were found ecchymosed and the small intestine congested. Frogs could be killed in the same manner.

There has been only one meeting of the Chemical Society (Nov. 5, 1868), and the space occupied by other matter compels us to defer an account of the proceedings until our next number.

6. ENGINEERING—CIVIL AND MECHANICAL,

And Notices of Recent Engineering Works.

One test of the vitality of the Engineering profession at the close of any year may be found in the list of plans deposited at the Private Bill Office for the ensuing session of Parliament. This year we are glad to find a marked improvement in this respect upon its predecessor, but still the list is not a very full one, and does not give promise of more than a very partial revival from the recent state of depression. The published list contains altogether one hundred and thirty plans, of which sixty are for railways, six for tramways, twenty-four for waterworks, twelve for gas, and the remainder for miscellaneous works of improvement. Amongst the railway schemes, the principal are proposed extensions of the present Metropolitan lines in and about London; a new line, to be constructed with unusual regard to economy in first outlay and in subsequent cost of working, between Brighton and London; and the constantly recurring proposal for a line under the Mersey, between Birkenhead and Liverpool.

The above are, however, works of the future, and such as may be carried out will receive their notice in these columns in due course. We must now turn our attention to giving a brief account of the principal works which have been completed, or in course of progress during the past quarter.

Docks, Harbours, &c.—The works of the Royal Docks at Cork Harbour are progressing very satisfactorily. It is expected that the foundation stone will be laid early in the spring of 1869. There are upwards of 400 convicts employed in various duties, as stone cutters, carpenters, and labourers; and there are in addition 100 men employed by the contractors.

The new Docks at Leith are fast approaching completion, water having already been admitted into them. The excavation of the outer basin is finished, and the quay walls are completed.

The Clyde trustees have decided on at once proceeding with the new Graving Dock at Salter's Croft, Govan, for which Parliamentary powers were obtained last session; and Messrs. Bell and Miller, C.E., have been instructed to take the necessary steps in preparing contract plans for the undertaking. The new dock will be one of the most extensive in the kingdom, capable of accommodating ironclads of the largest dimensions.

The harbour of Irvine, which has been gradually silting up for years, is now in course of improvement, and very extensive works are under construction for that purpose. Those under the first contract, which, however, comprise only a small section of those contemplated in the scheme of improvements and extensions, are nearly completed.

Leven harbour has long been acknowledged to be quite unsuited for the amount of shipping frequenting it, and as long as twenty years ago extensive improvements were contemplated. Nothing, however, has been done till quite recently; but workmen have at last commenced driving piles at the east end for the purpose of further extending it, and this will, no doubt, be followed by still greater improvements.

On 3rd September, a large floating-dock for Bermuda was successfully launched from the yard of Messrs. Campbell, Johnstone, and Co., of North Woolwich. It is 381 feet long, 124 feet wide, and 72 feet deep, weighing altogether nearly 9000 tons.

Railways.—The St. Pancras Terminal Station of the Midland Railway in London was opened on 30th September last. A description of this huge edifice was given in the last number of this Journal.

The new Railway between Glasgow and Coatbridge, in connection with the North British system, was commenced on the 28th September last. This line is to run direct west from Coatbridge, through the village of Bailliestown, and will be about eight miles in length. The entire line is to be completed by the year 1870.

The Duke of Sutherland has resolved to extend the Sutherlandshire Railway to Helmsdale. The necessary surveys have already been made, and works will be carried on in anticipation of the passing of an act early in the present session.

One of the contracts for the Greenock and Ayrshire Railway is expected to be completed before the end of the year, and the other early in the spring. The line will probably be ready for regular traffic in March or April next.

The East Kilbride Extension of the Caledonian Railway was formally opened to the public on 1st September last. The total length, from Glasgow to Kilbride, is ten miles.

The extension line of the South Yorkshire Railway, from Tinsley to Rotherham, was opened for traffic on the 1st September.

The New York Elevated Railway is expected to prove a great success. The section already completed was to have been opened on the 1st November; surveys have been completed for the remainder of the line, and the company will now proceed to raise money as fast as possible for its construction.

A railway to the summit of Mount Washington, New Hampshire, is now under construction. The station at the starting-point is 2700 feet above the level of the sea, and the road, when completed, will be 2 miles 260 rods long, rising in that distance 3000 feet to the Tip-top-house, with a gradient in some parts as steep as 1 foot in every 3.

The new line of railway between Suez and Alexandria, *viâ* Azazieh, was opened on 8th September. Passengers by the Indian mail will now proceed by that route, which will occupy only ten hours in transit, including stoppages.

Bridges.—The Quincy Railroad Bridge across the Mississippi, connecting the Chicago, Burlington, Quincy, and the Hannibal and St. Joseph Railroads, was opened for general traffic on the 7th November last. This bridge has been built to supersede the ferry, formerly the means of communication between the two lines which are now joined, and an unbroken route is obtained to the Missouri river, and westward to such lines as are constructed in Nebraska and Kansas.

An iron railway bridge is under construction between Louisville, Kentucky, and Jeffersonville, Indiana, which will be just one mile in length. It will have 24 spans, two of 370 feet, and six of 245·5 feet each. It is expected that this bridge will be completed by September 1st, 1869.

Water-supply, Drainage, &c.—During the last excessively dry summer several towns, including Liverpool, Manchester, and Edinburgh, were at one time apprehensive lest there should be a failure of their water-supplies, and this became more particularly felt in the two latter towns. We shall therefore probably soon hear of works being undertaken with the view of rendering available fresh sources of supply.

The works for giving an additional supply of water to the town of Preston were set in operation during the last week of August. The water is taken from the river Hodder, on the borders of Lancashire and Yorkshire, at a point thirteen miles from Preston. The total additional supply thus obtained amounts to 2,200,000 gallons a day.

The Kirkaldy and Dysart Waterworks are progressing favourably. It was expected that the whole of the works at Ballo would be finished by the 1st January, after which a commencement would be made in laying the pipes for the town.

A company recently formed for the utilization of the sewage of Liverpool has made considerable progress with the necessary works. Pipes have already been laid down to the extent of four miles, and it is expected they will shortly be carried out as far as Nice Blundell, where the distribution of sewage will first commence; the pipes will then be carried on to Southport. The deposit well at Sandhills has been sunk, and the pumping station immediately above it will soon be completed.

Miscellaneous.—Tenders have recently been invited for putting in the foundations of the New Fort to be erected on the middle ground-shoal in the Bombay Harbour. The fort is semicircular in plan, of a radius of 100 feet, the circular face fronting the mouth of the harbour. This will form part of a system of defensive works for the protection of Bombay Harbour, which was determined on some years back. Several of the minor works, comprehended in the defensive system, have already been completed.

A firm of gas engineers and contractors in New York have recently undertaken the erection of gas works at Canton, in China. The main building for retorts, &c., will be 184 feet long, made of iron, and manufactured after the most approved plans. The works will have a capacity to make 500,000 cubic feet per twenty-four hours. All the materials for the buildings, gasholder, and works will be made, fitted, and shipped complete, ready to be put up immediately on their arrival at their destination.

On 24th November the new Smithfield Meat Market in London was opened to the public with some ceremony, by the Lord Mayor and Civic Corporation. The market is a parallelogram, 631 feet in length by 246 feet in width, and covers 3½ acres. The general height of the external wall is 32 feet. There are 162 shops in the market, each about 36 feet by 15 feet; and behind every shop is an enclosed counting-house, with domestic apartments overhead. The lower part is filled in with broad glass louvres, so placed that while air is admitted freely the direct rays of the sun are kept out.

Mechanical.—Peet's stop-valve, which forms an admirable substitute for all other taps, stop-cocks, or stop-valves, is now being largely manufactured by Messrs. Joseph Whitley and Co., of the Railway Brass Works, Leeds. This valve has the advantage of giving an unobstructed line of communication when open, and when shut it comprises two steam-tight surfaces. The opposite internal sides of the valve are parallel, and instead of a single wedge-block, two separate discs are employed, which go down loosely to their bearing, when they are forced apart and driven close home by a conical end to the spindle. Thus, in the event of any obstruction preventing the proper closing of one of the discs, it in no way interferes with the other disc taking a perfect bearing.

A new method of applying steam to the propulsion of canal boats has been tested on the Erie canal. The driving-wheel is placed in the middle of the boat, and rolls on the bottom of the canal, being so arranged as to rise and fall with the irregularities of the bottom. The speed thus obtained is from two to two-and-a-half miles per hour.

A very useful invention has recently been patented by Mr. Andrew Murray, of H.M.'s Portsmouth Dockyard, designed for the purpose of hauling stranded vessels into deep water, in attempting to do which ordinary steam-tugs generally fail completely. The invention consists in fitting one or more powerful capstans on board a vessel which is to be placed between the stranded ship and one or more heavy anchors, laid out in the direction in which it is desired to move it. The capstans are fitted on the same bed-plate, and can haul upon both chains at once in opposite directions, thus bringing a very considerable pull upon the stranded ship.

A neat arrangement of cut-off gear, for enabling the degree of expansion in a steam-engine to be regulated by the governor, has recently been introduced by Messrs. Shelmerdine, Walker, and Holt, of the Albion Ironworks, Miles Platting, Manchester. In this arrangement the cut-off valve is placed at the back of the main slide-valve, and is moved by the latter by friction, the stroke of the cut-off valve being limited by a link coming into contact with springs on the stops. When the expansion-valve is stopped in this way the main slide travels on without it, and thus effects the cut-off of the steam; and the point in the stroke at which this stoppage of the cut-off valve takes place is regulated by raising or lowering the point of suspension of the link.

A new arrangement of stop-block for railway sidings, &c., is now being introduced by Messrs. E. S. Yardley and Co., of Manchester. The block, which is of cast iron, has bolted to it a pair of clips, which partially embrace two journals. The upper surface of the rail forms a portion of the bearings when the block is raised, but is left quite clear when the block is down. The block is raised and lowered by means of a sliding handle; this handle, when the block is raised, being locked by merely turning it one-fourth round. When the handle is thus turned a disc is exhibited, which indicates that the block is on the rails.

Mr. V. de Michele has lately introduced the simplest and most practical method of combining a screw motion with the ordinary reversing handle for a steam-engine that has yet been suggested. In this the handle works altogether independently of the screw, using its threads as notches. The screw arrangement is placed close below the frame of the engine on the centre of motion of the lever, leaving the handle as clear for ordinary rapid action as in the case of the simple lever.

Engineering Works.—The Chief Constructor of the Navy, Mr. E. J. Reed, C. B., has recently published a work on the subject of shipbuilding, entitled 'Shipbuilding in Iron and Steel,'* which professes to be "a practical treatise, giving full details of construction, processes of manufacture, and building arrangements; with results of experiments on iron and steel, and on the strength and water-tightness of riveted work." Unlike many previous publications of a kindred nature, this work deals with the question of shipbuilding from a purely practical point of view, and appears fully to carry out the author's intention of furnishing fuller information on the subject than has yet been published. The volume before us is divided into twenty-one chapters, of which fourteen are devoted to descriptions and illustrations of the details of iron and steel ships. One of the remaining chapters gives a description of the mode of work practised in building at the several private and the royal dockyards, and another relates to operations connected with armour-plating; whilst the remainder are filled up with matter of a purely practical character. It would be vain to attempt a perfect review of such a work as this within the space allotted to us, and we can therefore do little more here than notice its appearance. There are, however, one or two points of interest which should not be omitted. In this book, for the first time, we have a detailed account of the changes made in the construction of ironclads, from the 'Warrior' downwards. The arrangements adopted in most of the principal private establishments with respect to the various parts of iron ships are fully described; and separate accounts are given of the methods of iron shipbuilding adopted at the principal yards on the Mersey, the Thames, the Clyde, and the Tyne, as well as a full account of the system practised in the Royal Dockyards in building ironclads. The style in which this work is compiled seems well calculated to fulfil the author's expressed desire that it should be the means of affording information not only to shipbuilders in general, but more especially to the officers and workmen employed in the Royal Dockyards. By order of the Board of Admiralty it will form the principal text-book for examination in iron shipbuilding of candidates for promotion in the dockyards.

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* London: John Murray, Albemarle Street. 1869.

Although not exclusively an Engineering work, it may not be inappropriate to notice here an interesting French work, entitled 'Annales et Archives de l'Industrie au 19me Siècle.'* This work is one of the numerous publications that have arisen out of the Industrial Exhibition in Paris of last year. M. Eugène Lacroix is the well-known publisher of scientific works in Paris, and at the opening of the Exhibition he announced his intention of publishing a report on the Paris Exhibition, independent of all Government or other official authority and interference, much in the same manner as 'Tomlinson's Encyclopædia of Arts and Sciences' arose out of the first London Exhibition of 1851. The work at present under notice consists of a series of volumes, purporting to comprise a technology of arts, manufactures, agriculture, and mining, compiled from essays and reports upon the different classes of the Paris Exhibition of 1867, and forming a review of the present state and development of the various branches of industry and applied sciences and arts. The six volumes of which this publication consists certainly form one of the best records of the late Paris

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* Eugène Lacroix, éditeur. Paris: Quai Malaquais. 1868.

Exhibition printed in the French language, and it may very fairly be doubted whether there exists anywhere a more useful compilation of treatises on the present state of various branches of art and industry.

It would be impossible to do justice to M. Eugène Lacroix's 'Annales et Archives de l'Industrie' within the space allotted for the purpose; it may therefore suffice briefly to refer to the several subjects therein treated, which belong more particularly to Engineering Science.

A very interesting essay on the study of the influence which the fine arts exercise upon the progress and development of industries and manufactures should perhaps be noticed here, as it unquestionably bears intimately upon the question raised at the late Exhibition on the subject of technical education, having reference particularly to the comparative positions of different countries represented there. A most important subject treated in the various essays is one on Mining and Iron Smelting, by MM. Joulié and Dufrené. M. Michel Rous, Captain of Artillery, and M. Schwachlé have contributed a series of articles on the construction of firearms' ammunition, heavy ordnance, and other war materials, which are carefully illustrated with the most important designs exhibited at Paris. The articles on wood-working machinery, by MM. Raux and Nigreux, are accompanied by cuts of the most modern types of machines made in England, France, America, and Germany. Sugar manufacture and the different processes of brewing and distilling are treated by M. A. Basset and M. J. Grandvoinnet. The report on locomotives by M. Gaudry is illustrated with a series of drawings, showing the different types of engines exhibited, drawn all to the same scale; and a similar arrangement has been made in the case of portable engines. And finally we may refer to a well-compiled and carefully illustrated article on Naval Architecture, by M. G. de Berthein.

It is most important that foreign scientific publications should be carefully studied in this country as well as those by our own countrymen, and the fact that several of our continental neighbours are running us very close in competition for engineering works —albeit their best designs are but too often copies of English patterns—should make our engineers all the more anxious to borrow whatever of useful novelty may be found in their manufactures; and with this view we are glad to hail any addition to foreign engineering science.

A Practical Treatise on the Manufacture of Portland Cement, by Henry Reid, C.E.; to which is added a translation of M. A. Lipowitz's work, describing a new Method adopted in Germany of Manufacturing that Cement, by W. F. Reid.* The gradual increase of confidence in, and appreciation of, Portland cement as a building material, and the consequent additional demand for it, has, it appears, hitherto led to an insufficient care in its preparation, calculated to bring its properties into distrust. The object of the present work is primarily to remedy this evil, by instructing the manufacturers in the best practice of the process in all its details, and introducing into English manufactories the method at present adopted in Germany in that branch of industry. Considering how important a position good cement holds in almost all large Engineering works, any additional information calculated to lead to an improvement in its manufacture cannot but be accepted as a real boon. It will, of course, always be advisable that Engineers should sample, and carefully test, every delivery of cement employed upon their works; and it is only by such means, scrupulously carried out, that its manufacture is likely to be kept up to a desirable state of efficiency. Increased demand for a manufactured article too often leads to carelessness in its manufacture; and, as we have already said, it is only by persistent testings that a high standard is likely to be efficiently maintained. The present work shows how the manufacture of Portland cement may thus be successfully conducted.

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* E. & F. N. Spon: London, 1868.

7. GEOLOGY AND PALÆONTOLOGY.

(*Including the Proceedings of the Geological Society, and Notices of Recent Geological Works.*)

In last quarter's Chronicle we briefly noticed the publication in the 'Philosophical Magazine' of two instalments of Mr. J. Croll's paper on Geological Time. Its completion in the November number of that magazine enables us to give a *résumé* of the arguments, and the principal conclusions at which the author has arrived.

The question, How far the variation of the eccentricity of the earth's orbit may have brought about the great changes of climate indicated by geological phenomena, has been often discussed, more especially as regards the cause and date of glacial epochs. During the past three millions of years, there have been three periods when the eccentricity attained a high value. The first of these began about 2,630,000 years ago, and terminated about 2,460,000 years ago. The second began about 980,000 years ago, and terminated about 720,000 years ago. The third began about 240,000 years ago, and terminated about 80,000 years ago. The third period, Mr. Croll considers, was the date of the Glacial epoch; the second was that of the Upper Miocene period; while the third corresponded to the Glacial epoch of the Middle Eocene period. Few geologists believe that during the two latter periods our country passed through conditions of glaciation as severe as it has done during the Post-Pliocene period. Mr. Croll, however, argues that subaërial denudation, by destroying the whole of the land surfaces, has effectually removed all direct proof, although the indirect evidence is very much in favour of their occurrence. From calculations based upon the amount of sediment brought down by the Ganges, Mississippi, and other rivers, it would follow that from the close of the Miocene and Eocene Glacial periods to the present day, supposing the rate of deposition to be constant, 120 feet and 410 feet respectively have been removed and carried down to the sea in the form of sediment. The cosmical theory of climate also requires that if glacial conditions obtained at these periods, warm and equable climates must have prevailed immediately before or after them, and the author maintains that this is just what has happened. In the Turin Miocene, conglomerates considered glacial by Sir C. Lyell are overlain and underlain conformably by strata indicating a subtropical condition of climate. The same phenomena are also observed in Switzerland in rocks of the Middle Eocene period, where we find "flysch" closely associated with nummulitic strata, which contain genera characteristic of a warm climate. The Cretaceous and Permian periods afford similar evidence, and in the Post-Pliocene glacial period we have undoubted proof of a warmer climate during part of its duration, as evidenced by the occurrence of animals and shells existing in latitudes where they could not otherwise have lived in consequence of the cold. Space will not permit us to follow Mr. Croll any farther, but we would refer those of our readers who are interested in the subject to the paper itself, which will well repay a careful perusal.

The Woolhope Naturalists' Field Club is fortunate in having for its head-quarters a typical district in British geology, and it has, so far, taken advantage of its position as to publish in the new volume for the year 1867 two papers by the Rev. R. Dixon,—one on the "Geology of the Woolhope District," and the other on "Upper Silurian Fossils." The Woolhope district presents, according to Murchison, one of the best examples of a valley of elevation in the British Islands, and has even been referred to by Humboldt as an instance of the result of what he calls "Vulcanicity." By a continued volcanic action, the Upper Llandovery Sandstone has been upheaved some 9000 feet from its original position, into a dome-shaped mass, exposing on its flanks the superjacent rocks, which underlie the Old Red Sandstone. Fossils from the various beds are very numerous, and it was from the Woolhope Limestone of this district that the new Orthoceratite (*Actinoceras baccatum*), described by Mr. H. Woodward in a recent number of the 'Geological Magazine,' was obtained. The paper is accompanied by a list of the chief localities where the rocks are exposed, and by suggestions for routes which cannot fail to be of great service to future explorers of the district.

Vesuvius has acquired another historian, in the person of Mr. J. Logan Lobley, who has published a descriptive and geological account of that volcano. No new facts are adduced with which the previous writings of more eminent geologists have not already made us acquainted, but the appearance of the book is especially opportune, when Vesuvius, by another eruption, is again drawing to itself the attention of scientific men.

Palæontologists will be glad to hear of the appearance of the first part of the 'Ostéographie des Cétacés vivants et fossiles,' by MM. Van Beneden and Paul Gervais. We shall, however, defer our notice of the authors' conclusions until the completion of this, as it promises to be, important monograph.

In accordance with the recommendations of a Royal Commission, the Swedish Diet of 1856–57 voted, for a term of three years, a sum of money for a geological exploration of Sweden, and the publication of maps relative to it. Since 1858, owing to grants by future Diets, the work has gone on uninterruptedly, and during the ten years from 1858 to 1867 about 226 square miles have been explored and mapped. One of the results of this survey has been the publication, by Dr. Erdmann, of his investigation upon the Quaternary Formations of Sweden.* He considers that at the close of the first phase of the Glacial period, when the continental glaciers had attained their maximum development, and extended over the greater part of the country, the level of the sea was much lower than it now is, causing the region occupied by the Baltic and the Gulf of Bothnia to be part of the dry land. This was succeeded by an inverse movement,—the sea commenced to rise, and continued to encroach upon the land, until it reached, at the epoch of the transition between the Glacial and Post-Glacial period, a much higher level in some regions than its present limits. The waters then once again commenced to recede, and continued this movement until they had reached, little by little, their present level.

The Scientific Society to which Dr. Reynès intended to communicate the results of his investigations upon the geology and palæontology of the Department of Aveyron having been dissolved, he has published them at his own expense, and we now have before us his exhaustive treatise. Two-thirds of the department are occupied by igneous rocks, but in the arrondissements of St. Affrique and Milhau, the sedimentary rocks are represented by Upper Silurian, the Coal Measures, Permian, Trias (Bunter, Muschelkalk, and Keuper), Infralias, Lower Lias (Middle and

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* 'Exposé des formations Quaternaires de la Suède,' par A. Erdmann.

Upper), and Lower Oolite. Coal is found in the west of the department, immediately underlying the Permian rocks, and the thickness of the deposits makes the supply practically inexhaustible. Dr. Reynès believes that other localities only want working to yield coal, and that in St. Affrique especially the sandstone is so easy to mine that there would be great probability of remunerative success. Under the name of Lias, the author comprises the whole of the series of marls and limestones which extend from the top of the Trias to the Oolitic limestone. The Lower Lias (White and Blue Lias) is subdivided into six fossiliferous zones—(1) *Avicula contorta* zone (bone bed), (2) Zone of *Ammonites planorbis*, (3) Zone of *A. angulatus*, (4) Zone of *A. Bucklandi* (Arieten Kalk), (5) Zone of *A. obtusus*, (6) Zone of *A. oxynotus and raricostatus*, and *A. armatus;* the Middle Lias (Marlstone) comprises—(7) Zone of *A. fimbriatus*, and (8) Zone of *A. margaritatus;* and the Upper Lias (Upper Marls, Alum Shales, Possidonia Schists) consists of (9) Zone of *A. Serpentinus* (Possidonien Schiefer), (10) Zone of *A. bifrons*, (11) Zone of *A. jurensis*, and (12) Zone of *A. opalinus*. Several new species are described from these zones, principally from the zones of *A. margaritatus* and *A. bifrons*.

The attention of our palæontological readers is called to the publication of a work by Dr. Gustav L. Mayr, on 'Flies in Baltic Amber.'* We do not give a *résumé* of its contents, as the subject has only recently† been treated at some length in this Journal, in Dr. G. Zaddach's paper "On the Origin and History of Amber."

In the 'Annals and Magazine of Natural History' for November is a paper by Dr. H. A. Nicholson, "On the Distribution in Time of the Graptolitidæ." A careful examination shows that this order may still be considered characteristic of and confined to the Silurian period, notwithstanding the discoveries of the aberrant genus *Dictyonema* in the Middle Old Red of America, and in the Tremadoc slates of this country. The genera, and often the species of this order, are so constant in range and distribution, that they afford reliable data by which to correlate deposits in different parts of the world.

Another large group—the Brachiopods—has been treated in a similar manner by Mr. J. L. Lobley, in the 'Geological Magazine' for November. The vast range in time of this class, its persistence through varied conditions, and its apparent extinction during whole formations, such as the Trias, only to reappear when more favourable conditions obtained, would point to its study as being especially valuable in determining the truth and correctness of any development theory.

* 'Die Ameisen des baltischen Bernsteins.'

† 'Quart. Journ. Science,' vol. v., p. 167.

In the same number is an article by Mr. H. Woodward, "On a newly discovered Long-eyed Calymene, from the Wenlock Limestone, at Dudley." The eye-stalks of the new Trilobite are of remarkable length, and Mr. Woodward has given it the name of *Calymene ceratophthalma*.

Those who are specially interested in the subject, will find in the October number of the same magazine, a reprint of Mr. J. Evans's paper "On the Cavities in the Gravel of the Valley of the Little Ouse, in Norfolk," read before the British Association at Norwich, in which the supposed artificial cavities in or near which flint implements were found are referred to sand pipes.

The concluding portion of Mr. J. A. Phillips's "Notes on the Chemical Geology of the Gold-fields of California" is published in the December number of the 'Philosophical Magazine.' A careful examination of these gold regions has led him to arrive at the following principal conclusions. Quartz veins have been produced by slow deposition from aqueous solutions of silica on the walls of the enclosing fissures. The formation of these veins is often due to hydrothermal agencies, and it may be inferred that they are the result of an intermittent action, the fissures having been sometimes traversed by currents of hot water, and at other times having given off aqueous or gaseous exhalations. It would appear that gold may be deposited from the same solution which gave rise to the formation of the enclosing quartz, and the constant presence in auriferous veins of iron pyrites, which always contain a certain amount of gold, suggests the close connection of this sulphide with the solvent which holds the gold in solution.

In conclusion, we would call attention to the appearance of Dr. J. J. Bigsby's 'Thesaurus Siluricus—the Fauna and Flora of the Silurian Period,' a notice of which, in greater detail, will be found in another part of this Journal.

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

The memoirs published in the last number of the Society's Journal are unusually numerous and interesting.

In the secondary changes which have modified the chemical constitution of stratified rocks subsequent to their deposition, and produced the various forms of mottling and variegation, perhaps no agent has played so conspicuous a part as Iron. Mr. Maw, in an elaborately illustrated paper "On the Disposition of Iron in variegated Strata," has by a series of careful analyses determined many of the appearances connected with ferruginous rocks.

The state of combination in which iron is usually disseminated is the anhydrous sesquioxide, but it also occurs in small amounts as hydrous sesquioxide, carbonate of protoxide, and as silicates. Mr. Maw inclines to the opinion that the red sesquioxide was the primary condition of iron in red beds, rejecting Dr. Dawson's hypothesis that the sesquioxide was derived from the oxidation of bisulphide of iron under the influence of heat and moisture.

The bleaching of red beds and the pale blotches which so frequently occur in the midst of the primordial colour are invariably due to the abstraction of the colouring oxide, and in most cases appear to be entirely independent of any predisposing cause. The majority of examples of variegation in which there are neither mechanical nor segregated nuclei present, exhibit no differences in the light and dark parts, merely as regards the *proportion* of iron present, neither is there any change in the composition of the matrix, nor any alteration in the state of combination, except the invariable conversion of the red anhydrous into the hydrous sesquioxide. Of variegation in connection with joints or cracks, there are two distinct forms: one connected with surface infiltration, in which, along the line of joint, beds containing carbonate of protoxide of iron have become charged with the apparently insoluble sesquioxide; and the other, in which rocks coloured by the red sesquioxide have become bleached by its conversion into the protoxide.

The generally accepted theory, suggested by De la Beche, of the bleaching power of fossil carbonaceous matter by its reducing action upon the colouring oxide is not considered sufficient by Mr. Maw. Analyses lead to the conclusion that in these cases variegation results from a rearrangement of the iron, and not from its loss in a soluble condition, and that this rearrangement sometimes takes place centripetally and at others centrifugally.

The cause which has produced the banding of yellow sandstone seems to have been that instead of the hydrous peroxide of iron accumulating in spherical nuclei, the segregation has taken place in lines which have gradually advanced, gathering up the peroxide in their progress, and leaving behind them the bleached sandstone deprived of its iron.

The conclusions at which the author has arrived are that a very small proportion of the forms of variegation can be accounted for by the mere altered state of combination of iron, *in situ*, the alterations of the red anhydrous sesquioxide into hydrous sesquioxide, the reduction of sesquioxide to protoxide of iron, and occasionally the change of colour due to the decomposition of bisulphide of iron, completing the list of colour alterations due to a merely chemical change. Neither will the presence of organic matter account for the changes; and the author concludes that the transference of the colouring matter has taken place by the simple mechanical agency of segregation, principally, and also by infiltration and dissolution.

A paper by Dr. Leith Adams announces the discovery of the Asiatic elephant in a fossil state. The tooth, upon which the determination is based, was found by Dr. Duggan, at a distance of over forty miles from the sea-shore, between Kanagawa and Jeddo, in Japan, and at the base of a surface coal-bed. Mr. Busk, to whom Dr. Adams sent a plaster-cast of the specimen, considers it to be the antepenultimate upper left molar of what, if met with in the recent condition, he should undoubtedly refer to *Elephas Indicus.* The principal points of difference between the specimen in question and the similar recent molar, are its considerable curvature, its somewhat greater proportionate breadth, and the greater thickness of the plates. These differences, however, are unimportant, and there is every reason to believe that the Japanese fossil tooth belongs to a form of *Elephas Indicus,* with teeth somewhat larger than the average of the existing one.

In a paper by Dr. F. Stoliczka, "On Jurassic Deposits in the North-west Himalaya," the author combats the statement of Mr. Tate that he has failed to establish a true correlation between the Jurassic stages of the rocks of the Spiti valley and their European equivalents, which are all distinguishable by the characteristic fossils of their European analogues. Dr. Stoliczka has distinguished the following formations:—

1. Lias	*a.* Lower Tagling Limestone. *b.* Upper Tagling Limestone.
2. Dogger	*c.* Jurassic slates (not specified). *d.* Spiti shales.
3. Malm?	*e.* Gieumal sandstone.

The Lower Tagling limestone generally rests unconformably on the Lower or Upper Triassic limestone, while the Gieumal sandstone is overlain by Cretaceous rocks. Supposing the determination of the species to be correct, and Dr. Stoliczka is too good a palæontologist to make the matter doubtful, there can be no doubt that he has succeeded in proving that the Himalayan Jurassic rocks can be separated into determinate stages.

In a paper "On the Distribution of Stone Implements in Southern India," Mr. R. Bruce Foote describes the occurrence and position of the quartzite implements which are found in the laterite deposits of the eastern coast. These deposits, which are considered to be of marine origin, occupy the position of a belt, eight to ten miles in width, running parallel with the general coast line, and broken through by the different rivers running into the Bay of Bengal. This belt has been examined only from Ongole to Tanjore, a distance of 300 miles; but Mr. Foote states that it extends southward from the latter place, nearly down to Cape Cormorin, and on the north will probably be found to join the laterite of Orissa. The depth below its present level, to which the land was depressed, at the time of the formation of the lateritic deposits, would appear to have been very great. Laterite, containing implements, occurs at a measured height of 370 ft. above mean sea-level; and the author has found in the Alicoor hills several implements at a height of what could not have been less than 500 or 600 feet above the level of the sea.

Other implements have been discovered lying on the surface of the country, but at such great elevations (1400 feet) as to preclude the idea that they came from beds of marine origin. Mr. Foote considers that these were once enveloped in freshwater deposits, which have been removed by denudation. The quartzite pebbles, from which the implement makers drew their supplies to chip the various tools, came from the Jurassic conglomerates, which form the adjacent hills. These hills were probably islands standing up in the midst of the laterite sea, and were the homes of the manufacturers of the weapons and tools. The absence of any organic remains in the laterite precludes, however, the possibility of arriving at a satisfactory conclusion as to its age.

Dr. Holl, in a paper "On the Older Rocks of South Devon and East Cornwall," describes in great detail the extension and stratigraphical relationship of the different beds which lie to the south of the Carbonaceous rocks of Central Devon, and the adjacent parts of Cornwall. Neither the highest nor the lowest part of the Devonian system as seen in North Devon occurs on the south side of the Culm Measures, between which and the underlying Devonian there is a complete unconformity. The author divides the rocks of the district into three groups: Lower, Middle, and Upper South Devon groups. Of these the lower group extends from Dartmoor, by Hingston Down, to the Brown Willey granite, and may possibly be correlated with the base of the Ilfracombe group of North Devon. The discontinuous calcareous range of the Looe River, St. Germans, Brickfortleigh, Ashburton, and Bickerton, with the overlying slates, which separate it from the Plymouth and Torbay range, constitute the middle group. The upper group comprises the argillaceous slates, micaceous schists, and grits of Blagdon Cross and Kingsbridge promontory, and probably corresponds to the upper and Morthoe portions of the Ilfracombe series of North Devon.

8. METEOROLOGY.

The importance of the science of Meteorology is daily becoming more and more recognized; and its value to ourselves especially, as a maritime nation, is so great that we purpose henceforward to include it among our Chronicles. We shall commence by giving a brief account of the work which has been completed, both at home and abroad, during the past year, and of that which is now in progress.

Our own Meteorological Office, under the management of the Committee of the Royal Society, is now fairly afloat, and its first Annual Report was presented to Parliament in July last. The Report consists of two parts, of which one gives an account of the work of the office in London, under Mr. Scott, assisted by Capt. H. Toynbee as Marine Superintendent; while the other is a full description, with plates, of the self-recording instruments furnished by the Committee to their newly-established observatories. These latter are seven in number, *viz.* Aberdeen, Armagh, Falmouth, Glasgow, Stonyhurst, and Valencia, with the observatory of the British Association at Kew, under the management of Dr. Stewart, as the central and normal one.

The price of this Report is so extremely low (1*s.*) that we must refer our readers to its pages, and shall only notice it very briefly.

The work of the office is divided into three heads, *viz.* Ocean Meteorology, Telegraphic Weather Intelligence, and the Land Meteorology of the British Islands.

As to the first, the Committee have resolved to complete the discussion of the materials left in an unfinished state by Admiral FitzRoy and Mr. Babington, and, as a commencement of new work, to employ the energies of the office on the investigation of the meteorological conditions of the district lying between the trade-winds in the Atlantic Ocean.

From this inquiry, which will necessarily be a tedious one, owing to the immense arrear of observations to be worked up, it is hoped, as General Sabine, the chairman of the committee, states in his last presidential address to the Royal Society, to ascertain the "conditions of atmospherical pressure, temperature, and vapour tension, the direction and force of wind, the character of weather, and the sea-surface temperature," for each month and for each square degree over the area under discussion. Meanwhile, the co-operation of several of our leading ocean steamship companies has been obtained, and thereby a staff of observers of a very high class has been secured.

"Telegraphic Weather Intelligence" is the term applied by the committee to the system adopted in lieu of the old storm warnings. In June, 1867, they proposed, in answer to the request of the Board of Trade, to organize a system of telegraphy of *facts*, instead of *prophecies* or *forecasts*, and thereby to revert, for the present, to what had been originally contemplated when "storm warnings" were first instituted. At the end of the year, when the whole of the reporting stations had been visited, the arrangements were completed and the system was set in action. At present, General Sabine, in the address above quoted, informs us that the drum signal is hoisted at ninety-seven British stations, as well as at Hamburg and Cuxhaven; while telegraphic information of storms is also sent to Holland, and to the Ministry of Marine in France.

The first of the new observatories only commenced operations at the beginning of the present year, and we hope that ere long some results from these magnificent instruments may be communicated to the public.

The only other result of the work of the office which has as yet appeared has been a report by Mr. Scott, "On the Connection between Strong Winds and Barometrical Differences," which has been printed.

The inquiry was undertaken with a view of testing, by independent investigation of the weather reports published in 'The Times' for the period of nine months, the truth of the rule for foretelling the direction of the wind proposed by Professor Buijs Ballot. The rule has been very constantly brought before the public of late. It may be thus stated:—

Stand with your back to the wind, and the barometer will be lower on your left-hand side than on your right.

Accordingly if on any day the reading at Valencia is lower than that at London, we may expect southerly winds.

The report shows that strong winds are foretold correctly as to *direction* nine times out of ten, and as to both *direction* and *force* six times out of ten. It is shown that in the case of our great storms 90 per cent. of them gave unmistakable signs of their approach (in accordance with the rule) at least a few hours previous to their commencement. Serious storms never blow unless there be a considerable difference of atmospherical pressure within a limited area.

The results of the inquiry are fairly satisfactory, as a steady, though slight, advance in the direction of placing the study of weather on a firm scientific basis.

A notice of the pilot charts for the Atlantic, which have just been published by the Hydrographic Office of the Admiralty, is necessarily postponed.

In France, the magnificent series of charts—'Atlas des Mouvements Généraux de l'Atmosphère,' 1864, June to December, which has been issued by M. Le Verrier, next claims our notice. This consists of daily synoptic charts of the Atlantic Ocean from the equator to lat. 70° N., including, in addition, Europe and a few stations on the south and east coasts of the Mediterranean, and on the Atlantic seaboard of North America. The charts are constructed on the type of those which appear in the daily 'Bulletin

International' issued by the Observatoire Impérial; and they give for 8 A.M. every day the conditions of pressure, wind, sea-disturbance, and character of the sky, which have been obtained from ships' logs and land observations. The materials have been partly procured by the system of international co-operation; our own Meteorological Department and the Army Medical Department having contributed copies of observations furnished to them.

The value of a work like this for precise inquiries depends on the accuracy of the data furnished on the charts; and in this important particular we regret to say that the present Atlas leaves something to be desired.

It is naturally quite impossible to ensure absolute synchronism in the observations themselves, when the observers are scattered over so extended an area. Recourse must therefore be had to methods of interpolation, so as to reduce the results to what they would have been at 8 A.M. Paris time. This necessarily introduces a very serious amount of uncertainty. As regards the graphical representations, the isobaric lines have been drawn with a very free hand. In the preface M. Le Verrier says: "In the determination of isobaric curves the consideration of the winds is most important. They indicate to us the modifications which the curves undergo in the process of bringing themselves into harmony with each other, and explain to us sinuosities and irregularities which seem at first sight to have no apparent cause." Such an admission as the foregoing does away with the scientific value of these curves altogether. How is it possible to deduce any relation between wind and barometrical pressure, when the wind itself has been already taken as an important element in the determination of the course of those curves? This is arguing in a very limited circle indeed. However, the observations themselves appear to have been entered on the charts with all possible care, considering the difficulty of the preliminary calculations. The preface contains a most interesting account of the gradual development of the various meteorological undertakings carried on by the Observatoire Impérial.

In addition to this Atlas, two other volumes have appeared under similar auspices, the 'Atlas des Orages,' 1865, and the 'Atlas Météorologique,' 1866. These have reference almost exclusively to the distribution of thunderstorms and of hail over France during the years to which they respectively refer. The entire series of charts is most beautifully lithographed, and the whole is a valuable contribution to science.

Holland may take the next place, where the Royal Meteorological Institute at Utrecht, under the superintendence of Professor Buijs Ballot, assisted by Lieut. Cornelissen for the Marine branch, continues to work steadily, especially in the department of Ocean Meteorology. Owing to these publications being in Dutch, their various contents are not as available as might be wished to most British readers. Accordingly we hail with great pleasure the announcement contained in the Report of the Meteorological Committee, that it is intended to publish shortly an English edition of the temperature charts for the South Atlantic Ocean which appeared in the work entitled 'Ondersoekingen met den Zee-Thermometer,' Utrecht, 1861 (Researches with the Sea Thermometer). This year the attention of M. Cornelissen has been directed in a special way to the sea-surface temperature round the south point of Africa, where the alternations of cold and warm water are so frequently noticed—the domain of the dangerous gales of those seas. We are glad to say that this work has been published in English. It contains charts giving the temperature for each square degree during the different seasons, which are of great interest and value.

With regard to the land-work of the Institute, the Jaarboek (Year-book) has now reached its nineteenth annual volume.

In Prussia Professor Dove has brought out during the last two years the results of the monthly means of the meteorological elements for the four years 1864–67, with the five-day means of temperature, obtained by the discussion of the observations furnished by the Meteorological Institute, and also the first portion, relating to temperature, of a research into the climatology of North Germany for the last twenty years. The preface to this work contains much interesting information: we learn from it that the number of stations in connection with the Institute has now reached 160, and as the instruments have all been repeatedly verified, the data derived from them are to be thoroughly trusted. It is, however, very satisfactory to hear from Professor Dove, the highest living authority on the subject, that having compared carefully the results furnished by the present system with those obtained in previous years, before the Institute was in existence and consequently before the regular verification of the instruments had commenced, he finds that the conclusions yielded by the older materials are very slightly different from those now in process of deduction. The works in question, like the former ones of the Institute, have appeared as a portion of the publications of the Royal Statistical Bureau, and compose Nos. 12, 14, and 15 of that series.

North Germany is also commencing the work of Ocean Meteorology, and an office, entitled the Nord-deutsche Seewarte, has been established at Hamburg, under the superintendence of Herr W. von Freeden, formerly Rector of the Navigation School at Elsfleth, near Bremen. In fact the entire organization is to a great extent due to the energy of the Director, whose long experience of similar investigations leads us to cherish the best hopes for the success of the new undertaking.

In Norway Professor H. Mohn has recently furnished a number of stations, principally lighthouses, lying along the extended coast-line of that country, with instruments. Six of these possess telegraphic communication with Christiania. The organization of this system was commenced with the year 1867, and it is in connection with the Meteorological Institute of Norway, which, in itself, is affiliated to the University of Christiania. In addition to land observations, the Norwegian Marine has been solicited to take part in the work, and many of the sea-going captains have most cordially agreed to keep Meteorological Registers.

In Russia, and indeed in the world at large, Meteorology has sustained a most serious loss in the death of Professor Ludwig Kaemtz at the end of the year 1867. He had been only for two years Director of the Central Physical Observatory, having been appointed to that post on the death of Kupffer. The vacant position has since been filled by the appointment of Professor H. Wild, formerly at the head of the Observatory at Berne.

In Austria the K: K: Anstalt für Meteorologie und Erdmagnetismus has published the third volume of the new series of its Jahrbuch, being the results for 1866. Dr. Carl Jelinek, the Director of the Institution, tells us that the number of stations in connection with it has increased to 141. The volume is enriched by a most valuable paper by Professor Karlinski on the mean temperature of Cracow as deduced from forty years' observations.

Austria is also lending a hand to the work of Marine Meteorology, and has invited the co-operation of its own Navy and Merchant service.

In Italy the death of Matteucci has been a most unfortunate check to the development of meteorological organization, for although Secchi and others continue to issue their several publications, individually of great importance, there is as yet no central body under whose auspices these separate labours might be combined into a harmonious whole. This most desirable consummation seems sufficiently distant, but we may venture to express the hope that it will sooner or later be realized.

The result just alluded to was brought about in Switzerland in the year 1863, by means of a Meteorological Committee appointed by the Swiss Natural History Society. The system now comprises eighty-two stations, within a small area, but varying in their elevation above the sea, between 700 and 7600 feet. The Meteorology of Switzerland, and more particularly the question of the origin of the "Föhn," or south wind, whose action often causes such serious damage by floods, has been of late the theme of a warm controversy, and it may be hoped that the efforts now being made will help to elucidate this problem.

Our space will not allow of more than a passing reference to other countries, but we hear of meteorological organization in Denmark and also in Turkey, while the veteran Quetelet at Brussels, Aguilar at Madrid, and Capello at Lisbon, continue to publish the results of their respective observations.

Leaving Europe, we are glad to see that the United States are resuming the work suspended during the war, so that we may hope ere long to receive from the other side of the Atlantic valuable contributions in continuation of the work so energetically carried on in former days by Maury.

In our colonies the subject is generally attracting attention. The Government of Bengal has established a Meteorological office at Calcutta, of which Mr. H. F. Blanford has undertaken the superintendence, and has announced his intention of working at the meteorology of the Bay of Bengal. A system of storm warnings has also been set on foot.

The palm, however, of all work in those regions belongs to the Meteorological Society of the Mauritius, whose secretary, Mr. Charles Meldrum, is now in England, and engaged in the preparation of synoptic weather-charts for the Indian Ocean. Mr. Meldrum has read several valuable papers before various societies since his arrival in Europe, a notice of which must unavoidably be postponed.

We regret also to be unable on the present occasion to refer to the proceedings of the Meteorological Societies both in this country and in France, and can only hope hereafter to revert to the valuable researches contained in their journals.

9. MINERALOGY.

(*With Notices of Recent Mineralogical and Petrological Works.*)

To trace the progress of Mineralogy, quarter by quarter, would in truth be a cheerless task if the chronicler were restricted to the work that is carried forward in our own country. So little energy is brought to bear upon the study of British mineralogy, that many a month may pass without the publication of a single memoir worthy of being placed on record. Happily this state of lethargy has not extended to the Continent. There indeed scientific activity, not less in this department than in others, remains as rife as ever. In the periodical literature of continental science, Mineralogy occupies a position to which it is fairly entitled by its importance, but from which it is sadly degraded in this country. Hence it is, that the records regularly published in this Journal often contain so much about mineralogy abroad, but so little about mineralogy at home. As an introduction to the notes which we are about to offer in the present number, such an apology seems especially needful.

In a paper "On the Distribution of Microscopic Nepheline,"[*] Dr. Zirkel shows that this mineral, which a few years ago was regarded as peculiar to an exceedingly limited number of rocks, really enjoys a very wide-spread distribution, but that its crystals are in general so minute as to escape detection without microscopic aid. Nepheline usually occurs in six-sided prisms, and therefore its sections will appear as hexagonal or as rectangular plates, according as the crystals are cut transversely or longitudinally; whilst the rectangular sections will be either oblong or square, according to the height of the prism. When pure, nepheline is clear and colourless, but the larger crystals are usually more or less tinted by the presence of numerous grayish particles exceedingly minute, and variously disposed within the substance of the mineral: such particles are often accumulated in the centre of the crystal, and surrounded by a pellucid zone. When cut parallel to the principal axis of the prism, the sections often exhibit long lines of particles running in a longitudinal direction; and many of the crystals are also penetrated by tiny needle-like prisms of green augite. In microscopic examination, the observer must beware of mistaking crystals of apatite for those of nepheline, since the two minerals assume somewhat similar forms.

Having thus established the characters of microscopic nepheline, Zirkel proceeds to trace its distribution. Among the principal rocks in which he has detected it, may be mentioned the hornblende-andesite of the Wolkenberg and other hills of the Siebengebirge on the Rhine; the sanidine and oligoclase trachyte which forms the well-known "castled crag of Drachenfels"; the similar trachytes of the Cantal in Central France; the famous domite of the Puy-de-Dôme; and many of the trachytes and andesites which form so marked a feature in the geology of Hungary and Transylvania. It has long been supposed that certain basalts may contain nepheline, but Zirkel converts this supposition into a certainty: its presence in such rocks is however difficult to determine, and the sections need to be carefully prepared. Our Scotch geologists may not be aware that the greenstone of Arthur's Seat is remarkably rich in well-formed crystals of nepheline. Nor must it be supposed that the presence of this mineral is confined to rocks of any particular geological epoch, since it is found equally in the youngest eruptive rocks and in the oldest melaphyres.

Two new Silesian minerals have recently been described by Dr. Websky, of Breslau.[†] One of these is named, from its locality, *Kochelite*, whilst the other is to be called *Sarcopside*, in allusion to its resemblance to muscular tissue. Kochelite occurs as a brownish-yellow incrustation, with a columnar structure, investing titanic iron-ore and fergusonite. Its analysis, which is extremely complex, points to its chemical relations with yttrotantalite. The second mineral, Sarcopside, occurs in ellipsoidal masses invested with vivianite and embedded in granite. Internally these nodules exhibit a complicated structure, being made up of a reticulated arrangement of thread-like crystals, varying in colour from lavender to flesh-red. It is essentially a phosphate of iron and manganese, its analysis leading to the following unattractive formula:—

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[*] 'Ueber die Verbreitung mikroscopischer Nepheline.' Leonhard und Geinitz's 'Neues Jahrbuch für Mineralogie,' u.s.w. 1868. Heft VI., p. 697.

[†] 'Ueber Sarkopsid und Kochelit, zwei neue Minerale aus Schlesien.' Zeitschrift d. Deutsch. Geolog. Gesellschaft. 1868. Heft II., p. 245.

$$3\,PO_5\,(2\,Fe\,O,\,Mn\,O) + PO_5\,(2\,Mn\,O,\,Ca\,O) + Fe\,Fl + Fe_2\,O_3,\,HO.$$

For some years past extensive deposits of potash-salts have been worked in connection with the rock-salt of Stassfurt, in Prussian Saxony. Among these potash-salts—so valued by the agriculturist as fertilizing agents—the chloride of potassium in a compact state has long been found, and has passed under the various names of Leopoldite, Schätzellite, and Hövelite. *Sylvine* is, however, the mineralogical name by which the pure chloride is best distinguished. Of this mineral some splendid crystals have lately been found lining large drusy cavities in the Stassfurt deposits. The crystals—of which some of the faces measure a couple of inches across—are combinations of the cube and octohedron, and exhibit a perfect cubic cleavage. In appearance they strongly resemble rock-salt, but are distinguished by a somewhat sharper taste. Although usually colourless, they are sometimes tinged red, either by mechanical enclosure of oxide of iron, or by the presence of a gaseous substance, probably marsh-gas. The crystals are almost pure potassium chloride, containing only a small percentage of the chlorides of sodium and magnesium, with traces of the sulphates of soda and magnesia. A notice of the mineral has been laid before the German Geological Society by Herr Huyssen.*

Availing himself of these crystals of sylvine—unparalleled as they are for size and transparency—Professor Magnus has been enabled to examine the effect of chloride of potassium on radiant heat.† He finds its behaviour to be precisely similar to that of the analogous sodium compound; both minerals being highly diathermanous, irrespective of the temperature of the source of heat. Sylvine is thus entitled to share the appellation hitherto enjoyed solely by rock-salt—that of "the glass of radiant heat."

Mr. J. R. Gregory has just returned from a mineralogical tour in South Africa, having been commissioned by Mr. Harry Emanuel, the well-known jeweller, to examine the reputed diamond districts of that country.* As the rocks which he traversed were for the most part amygdaloidal traps, it is highly improbable that they would ever yield diamonds or other gems; and hence he concludes that the alleged discoveries are purely deceptive, all the stones exhibited as Cape diamonds having been previously imported from other countries. Mr. Gregory also hints that the African *El Dorado* is equally visionary. That gold exists in South-eastern Africa, every traveller admits; but that it exists in quantity sufficient to render its working remunerative, Mr. Gregory is evidently inclined to doubt. It is only just to add that an attempt has been made to refute these statements, tending, as they so inevitably do, to the prejudice of the colony.†

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* Zeitschr. d. deutsch. geolog. Gesellsch. 1862. Heft II., p. 460.

† 'Comptes Rendus,' 1st Sem., No. 26, p. 1302; 'Phil. Mag.,' Oct. 1868, p. 320.

Although Mr. Gregory brings home neither diamonds nor gold-dust, some of his South African specimens are not without interest. One of these is a meteorite, weighing 2 lbs. 5 oz., which fell on the 20th March, 1868, at Daniel's Kuil, Griqua territory. Its fall was witnessed by a native Griqua, who picked it up whilst still warm. In composition it is a meteoric stone, through which much free iron is disseminated, in association with troilite, schreibersite, &c. As but few African meteorites are known, we give Professor Church's analysis of this stone.‡

Nickel-iron	29·72
Troilite	6·02
Schreibersite	1·59
Silica and Silicates	61·53
Oxygen, other substances, and loss ..	1·14
	100·00

A new mass of meteoric *iron* from South Africa is also noticed by Mr. Gregory. It fell in 1862 at Victoria West, and is now exhibited in the Museum at Cape Town.

Some interesting questions are suggested by Kenngott's study of a Swiss specimen of limestone, which exhibits a drusy cavity containing gypsum and anhydrite. As it can hardly be supposed that these two minerals—the one hydrous and the other anhydrous—were of contemporaneous formation, it becomes a point of interest to determine which of the two was the earlier formed. Kenngott, after a lengthy discussion, concludes that the cavity was first filled with anhydrite, from which the gypsum has been derived by hydration.§

Under the euphonious name of *Aquacreptite*, Professor Shepard describes a massive mineral found at West Chester, Pennsylvania.‖

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* See 'Quart. Journ. of Science,' Jan., 1868, p. 107.

† 'Journal of the Soc. of Arts,' Nov. 13th and 20th, 1868.

‡ 'Geolog. Mag.,' Nov., 1868, p. 532.

§ 'Neues Jahrbuch.' 1868. Heft V., p. 577.

‖ 'Silliman's American Journal,' Sept., 1868, p. 256.

In external characters it resembles the Tuscan miemite, but in composition it is a hydrous silicate of magnesia, iron, and alumina. Its name is suggested by the decrepitating sound which the mineral emits when thrown into water, especially if the liquid be warm.

The Professor also calls attention to a new meteorite which has been ploughed up on a farm near Losttown, Cherokee County, Georgia.* It weighs 6 lbs. 10 oz., contains abundance of nickel, and when etched exhibits the "Widmannstättian figures."

Perhaps the chemist, rather than the mineralogist, will be interested in a paper by Mr. J. E. Reynolds,† in which he attempts to introduce a new mode of expressing symbolically the chemical constitution of the mineral silicates,—a mode which he conceives to be free from the objections which may fairly be urged against the notations recently introduced by Odling, Frankland, Dana, and others.

Signor Bombicci describes, among other Italian minerals, a new calcareous serpentine to be called *Barettite,* after its discoverer Baretti; and an impure allophane remarkable for containing lead, and hence named *Plumboallophane.*‡

Many analyses of the triclinic felspars, labradorite, and oligoclase, have been published by Herr König, of Freiberg.§ The chemical examination of some Italian augites will be found in a recent memoir by Vom Rath.‖

Rammelsberg has published a paper on the composition of apophyllite and okenite,¶ and another on the phonolite of Mont Dore.** Finally, we may mention that Dr. Sandberger announces the discovery of tridymite in the trachyte of the Drachenfels.††

New Works on Mineralogy.—It has been well said that over the portals of Mineralogy might fitly be inscribed the famous motto placed by Pythagoras at the entrance to his school of philosophy, "Let no one enter here who is ignorant of Geometry." Indeed, to master the difficulties of crystallographic science, which early beset the path of the mineralogical student, a fair acquaintance with solid geometry is imperatively demanded; whilst the study of some of the more refined systems would be undertaken in vain without the assistance of spherical trigonometry. Every one, however, does not fall in love with

> "The hard-grained Muses of the Cube and Sphere;"

and hence it can hardly be expected that crystallography will ever become a popular study. Nevertheless, its value in the diagnosis of mineral species—a value recognized even by those who are least inclined to revert to the school of Mohs—should be sufficient to call for its assiduous cultivation on the part of all who are interested in mineralogical science. Crystallography is indeed nothing but the morphology of the mineral world; and the one is every whit as needful to the mineralogist as the other is to the biologist. To those, however, who take up the study of mineralogy, not for its own sake, but merely as an aid to the science of geology or to the art of mining, a very moderate knowledge of rudimentary crystallography is all that can be expected, or is indeed necessary. Such a knowledge may well be gained from the little 'Guide to Descriptive Crystallography,' recently written by Hochstetter and Bisching for special use in the study of mineralogy.* Issued without a preface, the work speaks for itself as an able and concise introduction to the science, which, though limited in its scope, is nevertheless sound and trustworthy. After a discussion of the general ideas which lie at the root of the science, the work deals in succession with each of the six "systems," or groups of related forms into which all crystals are capable of division, and treats of both the holohedral and hemihedral forms, together with the more important of their combinations. The system of notation employed throughout the work is that of Naumann, which still holds its ground as a favourite with most beginners; but as the book is published in Vienna, where Grailich's translation of 'Miller' is extensively read, it is not surprising that Miller's symbols are also given. The work is illustrated by a profusion of woodcuts, and indeed without ample illustration such a subject would be well nigh unintelligible.

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* 'Silliman's Journal,' Sept., 1868, p. 257.

† 'Phil. Mag,' Oct., 1868, p. 274.

‡ 'Atti della societa ital. di scienze nat.,' XI.

§ Zeitsch. d. deut. Geol. Gesell. 1868, p. 365.

‖ Ibid., p. 265.

¶ Ibid., p. 441.

** Ibid., p. 258.

†† 'Neues Jahrbuch,' 1868, p. 723.

Perhaps no mineralogical treatise enjoys a more extensive circulation as a text-book than Naumann's 'Elements.' The seventh edition of this work, enlarged and improved, now lies before us.† Of a book so well known little need be said. The first section contains an outline of crystallography, which is certainly not the least valuable part of the work. This is followed by a description of the physical properties of minerals, and an introduction to their chemical characters. The second part—which forms by far the larger portion of the book—is devoted to systematic mineralogy, and after some preliminary ideas on the principles of classification, proceeds with the physiography of species. As descriptive mineralogy advances, this part of the work necessarily increases in its proportions, and a glance at the index is sufficient to show that among the many new species—or reputed species—constantly being brought to light, there are but few that escape the notice of the great crystallographer of Leipzig.

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* 'Leitfaden der beschreibenden Krystallographie. Zum Gebrauche bei dem Studium der Mineralogie.' Von Dr. F. Hochstetter und A. Bisching. 8vo. Vienna, 1868, pp. 85.

† 'Elemente der Mineralogie.' Von Dr. Carl Friedrich Naumann. Siebente, vermehrte und verbesserte Auflage. 8vo. Leipzig, 1868, pp. 566.

A laborious compilation, by Dr. Websky, of Breslau, claims a passing notice as the first of a series of mineralogical monographs.* This is little else than a bald list of all the known mineral species, classified in groups according to their specific gravities, commencing with Pyropissite, which has a density as low as 0·493, and ending with Iridosmium, with a density as high as 21·2. The specific gravity is usually accompanied by the hardness, and sometimes by the chemical composition of the mineral. It is supposed by the author that the few characters here given will be sufficient to guide the student in the determination of species.

New Works on Petrology.—Probably it would be difficult to point to any branch of natural science which at the present time occupies a more unsatisfactory position in this country than that science which, according as it is pursued in the field or in the cabinet, has been variously designated *Petrology* or *Lithology*; in other words, the study of *rocks* as distinguished from that of *minerals*. Whilst we have pursued stratigraphical geology in a spirit worthy of the countrymen of William Smith, and have prosecuted the study of fossils with such vigour, and consequently with such success, that British palæontologists and their writings enjoy a world-wide reputation, it is strange that the complementary science of petrology should have fallen into unmerited neglect, and that in this department our best geologists should be found sadly wanting when weighed against their brethren of the hammer in other lands. Place, for example, the Journal of our own Geological Society by the side of the *Zeitschrift* of the corresponding German Society, and our shortcomings on this point are all too plainly seen. The geologist, therefore, who would describe with accuracy the rocks that are forced upon his observation in the course of his daily work, must needs betake him to the fields of continental literature, where the fertility that has been evoked by many a painstaking labourer strikingly contrasts with the sterility at home. Especially in the rich literature of Germany does he find no lack of treatises which exhibit that happy combination of chemical, mineralogical, and geological knowledge, without which the study of petrology would be next to impossible. Not to mention a host of minor writings, it is sufficient to point, in support of our assertion, to the admirable works of Senft and Zirkel. As a fit introduction to these comprehensive treatises, it is our duty to call attention to a useful little work recently written by Dr. Kenngott, of Zurich.*

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* 'Die Mineral-Species, nach den für das specifische Gewicht derselben angenommen und gefunden Werthen. Ein Hülfsbuch zur bestimmenden Mineralogie.' Von Dr. Martin Websky. 4to. Breslau, 1868, pp. 170.

Those who are unable to wade through the larger volumes will here find an excellent outline of modern petrography. In the early chapters the author gives as much elementary mineralogy as he considers needful as an introduction to petrology. When we remember that it is to the want of mineralogical training on the part of most geologists that the backward state of petrology must mainly be referred, the propriety of such an introduction is at once evident. A chapter then follows on the general relations of rocks, in which are discussed their mineralogical constitution, physical structure, and probable mode of original formation and subsequent alteration. The writer then proceeds with the systematic description of the different species of rocks, and, without any pretence to originality, goes over much the same ground as is usually covered by the larger treatises. It should be remarked that in expressing symbolically the chemical constitution of rock-forming minerals, he introduces the new atomic weights, whilst he retains the old method of rational formulæ. The propriety of this seems questionable. Good geologists are, as a rule, bad chemists; and much confusion may therefore arise on comparing Kenngott's formulæ with those given in other mineralogical works. In dismissing the book, it is only necessary to notice its unusually full index—an index which in some measure plays the part of a supplement, inasmuch as it contains short descriptions of unimportant rocks which find no place in the body of the work.

Whilst Germany, without doubt, takes the lead in petrological science, France occupies a position far from discreditable, as amply testified by the writings of such men as Daubrée, Durocher, Coquand, and Delesse. Among her most ardent students must be numbered the late M. Cordier, who for more than a quarter of a century devoted himself to the study of rocks. At once an accomplished mineralogist and an experienced traveller, Cordier was well fitted to examine his specimens by the most minute and exact methods, while he was kept from those narrow generalizations in which the mere worker in the cabinet is too prone to indulge. His collection of rocks, now deposited in the Geological Gallery of the Museum of Natural History in Paris, numbers no fewer than ten thousand specimens, each said to represent a distinct variety! To classify this myriad of specimens with scientific accuracy was the great end of Cordier's life. Although mineralogical composition was the leading feature of his system, he was far from relying solely on any single characteristic—whether chemical, physical, mineralogical, geological, or genetic—

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* 'Elemente der Petrographie, zum Gebrauche bei Vorlesungen und zum Selbststudium, bearbeitet von Dr. Adolf Kenngott.' 8vo. Leipzig, 1868., pp. 274.

but looking at the *ensemble* of these characters, he sought to establish a "natural" method of classification, following in the wake of Jussieu, and doing for petrology what has already been so ably done for botany. A description of his system has recently been published as a posthumous work, edited by his colleague, M. Charles D'Orbigny.*

The work is divided into three parts, in the first of which we learn the characters of rocks in general, the principles on which their species and varieties are founded, and the method followed in their classification. In connection with this section attention may be called to a chapter on the determination of compact volcanic rocks, which is the reproduction of an essay published as far back as 1815. The second part gives a systematic and detailed description of all the known rocks that compose the solid crust of the earth. In this section many new species are described, and one meets for the first time with such names as Harmophanite, Syenilite, Cristulite, Leucostite, Mimotalcite, Cecilite, &c. The third part contains some general considerations on the constitution of the earth's crust, and a description and classification of the crystalline rocks. Possibly the value of the book would not have been much diminished if this portion had been omitted, or at least considerably modified. As a testimony, however, to the practical value of Cordier's system of classification, the editor tells us that he has found by long experience that from fifteen to twenty lessons on this method are always sufficient to enable a student to determine a rock at sight, even when he commenced the study ignorant of the first principles of Mineralogy.

10. MINING AND METALLURGY.

Mining.

The shortness of the average duration of a miner's life has often been the subject of the most serious consideration. The Royal Commission, of which Lord Kinnaird was the chairman, made this portion of their inquiry a most searching one. It is clear, from the evidence given by medical men and others, that the metalliferous miner suffers in health from climbing on the perpendicular ladders from great depths, from working in air deficient in oxygen, and from the severe labour of boring holes for blasting in confined levels. The constrained position of the man in "beating the borer," and the muscular effort necessary to deliver the heavy blow, acts injuriously upon the heart and lungs. The miner has been relieved to some extent from the effects of climbing by the introduction of the "man-engine" (a movable rod with platforms fixed upon it, by which the miner is gradually lifted—without fatigue to himself—from any depth to the surface). The ventilation of the mines generally has been improved, but it is only within the present year that any actual experiment has been made in the mines on the use of machines for boring holes, worked by compressed air or steam. We have been favoured, upon application, with the following report. We are glad to place this on record, as the commencement of an application of machinery to a most important purpose. We have no doubt that in a short time boring-machines will be generally adopted in our metal-mines.

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* 'Description des Roches composant l'écorce terrestre et des terrains cristallins constituant le sol primitif.' Ouvrage du feu P. L. A. Cordier, par Charles D'Orbigny. 8vo. Paris, 1868, pp. 553.

"Dœring's rock-boring engine has been worked on the 185 fathom level in Tincroft Mine, conjointly with another, from the 6th January up to the present time, and has driven sixteen fathoms in hard Tin Capel, which Captain Teague considers would cost 20*l*. per fathom if driven by hand-labour.

"During the greater part of this time, in consequence of the air-pumps getting constantly out of repair, the machine was only worked by one (shift) corps of two men; and continuous working with three corps, comprising five men and one boy, only commenced on the 6th July.

"Since this date nearly nine fathoms of ground have been driven, at a cost of 17*l*. 16*s*. 2*d*. per fathom.

"The following is the cost of working the machine during the last month:—

	£	*s.*	*d.*
Five miners and one boy	24	0	0
One boy to remove rubbish	2	0	0
Two enginemen at surface	6	0	0
One smith and boy	5	5	0
Oil, waste, and candles	3	9	0
Gun-cotton for blasting	4	10	0
Fuse	0	7	6
Sundries	0	3	0
Coals	6	0	0
Repairs	2	0	0
	£53	14	6

"In the above estimate the sum of 21*l*. 5*s*. is for expenses at the surface, which would be but slightly increased if three ends were driven instead of one—say about 2*l*. 15*s*. This would reduce the average cost per fathom to 13*l*. 9*s*. 10*d*., instead of 17*l*. 18*s*. 2*d*.

"During these last three months one corps has been worked by one man and a boy, and the result has shown that they will drive as much ground with the machine as two men could do in the same time.

(Signed) F. B. Dœring."

We find, during a recent visit to the Cornish mines, that the patentee is offering to contract for sinking shafts and driving levels upon such terms as will, without doubt, induce many mine adventurers at once to close engagements with him.

General Haupt's machine for boring is about to be introduced into the lead mines of Swaledale, in Yorkshire; and Mr. Lowe's machine is in use in several large railway cuttings and tunnels.

The severe depression which has for the last two years pressed so heavily on copper and tin mines in this country is happily passing away. The prices of metals have improved, and hence the increased value of the ores. The demands for tin and copper are becoming more active. The imports of these metals have declined; hence the improved demand for British minerals. It should not be forgotten, however, that this state of things is not likely to last. South American copper-ores will soon flow into our markets, the countries producing them—Chili and Peru—having recovered from the disturbances which have of late interrupted every industry and impeded commerce. The East Indian tin will be imported in large quantities from Banca and Billaton as soon as the improved prices will yield to the Dutch adventurers a profit.

Our miners must, therefore, direct their attention towards the application of machinery, so as to economize in every direction—not merely in the subterranean mining, but in all the surface operations.

Necessity—the mother of invention—has already done much in this way; but there is yet ample room for very considerable improvement in the modes of working our mines, and in the methods of dressing the ores for the market.

In connection with this subject we may name—as we do with satisfaction—the increased desire on the part of the Cornish miners to avail themselves of the many advantages offered to them by the Science Classes of the MINERS' ASSOCIATION OF CORNWALL AND DEVONSHIRE. We learn that four classes are now in operation in the mining districts around Helston, in which sixty working miners are proving themselves apt students of Chemistry, Mineralogy, Geology, and Mechanics. One class of nearly thirty is no less actively engaged at Redruth, another in the mining parish of Gwennap, while a seventh has recently been formed in the northern portion of the important mineral district of St. Just. The advantages which must result from these classes will, ere long, be felt in the improvement of mining and in the elevation of the miners.

A report on the Mineral Statistics of Victoria has been recently published. From this report we glean the following particulars:—In 1859 there were 125,764 miners employed on the gold-fields; in 1867 there were only 63,053 so employed. The average earnings of the miners per man per annum have increased from 79*l.* 9*s.* 3*d.* in 1860 to 87*l.* 1*s.* 7*d.* in 1867. The mean of eight years is about 76*l.* 1*s.* per man. Yet the "thirst for gold" leads men from all parts of the world to endure all the privations and the hardships of a gold-miner's life for this miserable reward. The value of the metals and minerals raised in the colony of Victoria since the discovery of the gold-field has been estimated as follows:—

	£
Gold, 33,910,052$\frac{3}{4}$ oz.	135,643,811
Silver, 12,591 oz. 18 dwts.	3,460
Tin	195,045
Copper	4,673
Antimony	30,426
Coal, 1933 tons, at 1*l.* 10*s.* per ton	2,899
Lignite, 235 tons, at 17*s.* 6*d.* per ton	205
Kaslin, 1757 tons, at 4*l.* per ton	7,028
Flagging	18,663
Slates	508
Magnesite, 6$\frac{1}{4}$ tons, at 2*l.* per ton	12
Diamonds, about 80 carats	80
Sapphires	150
Total value	£135,906,960

The quantity of gold exported in 1867 was 1,433,687 oz., of which 560,527 oz. were obtained from quartz veins, and 873,160 oz. from alluvial workings.

The explosions of fire-damp in some of the coal mines of France has naturally drawn attention to the subject of ventilation. M. Galy-Cazalat, who has brought the matter before the Académie des Sciences, proposes the construction of vertical air-pits, the purpose of which would be to draw off the carburetted hydrogen as rapidly as it is formed, and thus prevent its mixing with the air of the mine. These "*cheminées d'aspiration*," as he calls them, will scarcely require very special description, the whole plan really resolving itself into a greatly increased number of shafts, by which the air in every part of the mine may be rapidly changed. There can be little doubt that great advantages would arise from such a system; but in the large and deep collieries of this country there are many serious difficulties standing in the way of its introduction.

M. Delaurier has brought before the Academy of Sciences a plan for *destroying* fire-damp in coal-mines. He proposes to place copper conductors of considerable thickness in the galleries; these are to be broken at intervals, and united by means of very thin gold wire, which is to be covered with sulphur. By passing a strong current of electricity through those conductors, the sulphur is ignited, and if any fire-damp be present it will be fired. This idea is by no means new. The Academy is said to have spoken approvingly of the proposed plan; but all coincided in the opinion that regular and powerful means of ventilation could in no case be dispensed with. The combustion of the *fire-damp* would produce *choke-damp,* which it would be necessary to remove. This plan, like many others which are from time to time brought forward, evidently originated with one who was but imperfectly acquainted with the conditions under which fire-damp is formed in a colliery.

The Pitch Lake of Trinidad ever and anon claims the attention of the public. At one time it is introduced as the source from which all the varieties of mineral oil, paraffine, and asphaltum can be obtained. At another period it is to be employed to give greater illuminating power to our coal-gas, and some experiments of the Hon. Captain Cochrane, made at Woolwich, were highly favourable. Now we have the pitch of Trinidad coming before us as an ingredient in artificial fuel for steamers. The bitumen is mixed with a certain quantity of charcoal; it is ground, and then made into bricks. Experiments made on board H.M.S. 'Gannet,' Commander Chimmo, appeared to show that it possessed many valuable properties, but the amount of ash, arising from the earthy matter mixed with the petroleum, was somewhat objectionable. This can, however, in all probability, be obviated by greater attention in the process of manufacture.

The Sicilian sulphur mines have been long known. More than 600 mines have been at work, and at least 200 worked out and abandoned. The mining is of the most primitive character, the use of machinery being extremely limited. Not less than 22,000 people are occupied in working those mines, and the result is the production of sulphur to the value of not less than 17,600,000 francs per annum. The sulphur ores of Spain are now largely imported into this country, and during the year not less than 500 tons of copper have been separated from sulphur-ash, after the sulphur has been expelled by burning, although the pyrites does not contain more than from 1 to 2 per cent. of that metal.

METALLURGY.

There is but little worthy of notice in the Metallurgy of the quarter, beyond the cheerful intelligence that in every branch there are evidences of a very decided improvement.

One process—that of Mr. Heaton—for the conversion of iron into steel, has been attracting considerable attention. Experiments have been in progress at Langley Mills, and the results are certainly of great promise. The process is conducted as follows:—Cast iron of any quality is first melted in a common iron-foundry cupola with coke fuel. A known quantity of the liquid iron—usually about a ton—is tapped out into an ordinary crane ladle, which is swung round to the side of the converter. This latter is a tall cylinder of boiler-plate, open at the bottom, between which and the floor a space is left. The converter has a fire-brick lining, and terminates in a conical covering, out of which an iron funnel opens to the atmosphere. In the bottom of the converter a number of short cylindrical pots, lined with brick and fire-clay, are adjusted. Into these pots a given weight of crude nitrate of soda of commerce is put. The surface of the powder is levelled, and covered by a thick circular plate of cast iron. One of these pots thus prepared having been adjusted to the bottom of the cylinder, the converter is now ready for use. At one side of the cylinder is a hopper, covered by a loosely hinged flap of boiler-plate. This plate is raised, and the ladle full of liquid cast iron is poured into the converter, and descends upon the top of the cold cast-iron plate. The plate does not float up nor become displaced, nor does any action become apparent for some minutes, while the plate is rapidly acquiring heat from the fluid iron above it, and the nitrate getting heated by contact with it.

Professor Miller, of King's College, thus describes the process:—"In about two minutes a reaction commenced; at first a moderate quantity of brown nitrous fumes escaped; these were followed by copious blackish, then grey, then whitish fumes, produced by the escape of steam, carrying with it, in suspension, a portion of the flux. After the lapse of five or six minutes deflagration occurred, attended with a roaring noise and a burst of a brilliant yellow flame from the top of the chimney. This lasted for about a minute and a half, and then subsided as rapidly as it commenced. When all had became tranquil, the converter was detached from the chimney, and its contents were emptied upon the iron pavement of the foundry. These consisted of crude steel and of slag. The crude steel was in a pasty state, and the slag fluid; the cast iron plate had become melted up and incorporated with the charge of molten metal. The slag had a glassy blebby appearance, and a black or dark green colour in mass."

Professor Miller's report gives the following results of analysis of three samples of metal produced at the Langley Mills under his own observation:—

	Cupola. Pig (4).	Crude. Steel (7).	Steel Iron (8).
Carbon	2·830	1·800	0·993
Silicon, with a little titanium	2·950	0·266	0·149
Sulphur	0·113	0·018	traces
Phosphorus	1·455	0·298	0·292
Arsenic	0·041	0·039	0·024
Manganese	0·318	0·090	0·088
Calcium	..	0·319	0·310
Sodium	..	0·144	traces
Iron (by difference)	92·293	97·026	98·144
	100·000	100·000	100·000

"It will be obvious, from a comparison of these results, that the reaction with the nitrate of soda has removed a large proportion of the carbon, silicon, and phosphorus, as well as most of the sulphur. The quantity of phosphorus (0·298 per cent.) retained by the sample of crude steel from the converter which I analyzed is obviously not such as to injure the quality. The steel iron was subjected to many severe tests. It was bent and hammered sharply round, without cracking. It was forged and subjected to a similar trial, both at a cherry-red heat and at a clear yellow heat, without cracking; it also welded satisfactorily." The Professor concludes his report by stating that Heaton's process is based upon correct chemical principles, and that the mode of attaining the result is both simple and rapid.

Mr. Robert Mallet and Mr. David Kirkaldy have both made reports of the most favourable character upon this process and its results.

11. PHYSICS.

Light.—All the researches on this subject which have been published for some time past, have been thrown in the shade by some researches on a new series of chemical reactions produced by light, which have just been communicated to the Royal Society by Dr. Tyndall. He has investigated the action of a concentrated beam of light on vapours of volatile liquids, and has obtained some very striking phenomena of decomposition. A glass tube 2·8 feet long and of 2·5 inches internal diameter was supported horizontally. At one end of it was placed an electric lamp, the height and position of both being so arranged that the axis of the glass tube and of the parallel beam issuing from the lamp were coincident. The tube was closed by plates of glass; it was connected with an air-pump and also with a series of drying and other tubes used for the purification of the air. The experimental tube being exhausted and the cock which cuts off the supply of purified air being cautiously turned on, the air entered the tube bubbling through a liquid whose vapour was to be examined. The power of the electric beam to reveal the existence of anything within the experimental tube, or the impurities of the tube itself, is extraordinary. When the experiment is made in a darkened room, a tube which in ordinary daylight appears absolutely clean is often shown by the present mode of examination to be exceedingly filthy. The first experiment was tried with nitrite of amyl. The tube being exhausted, a mixture of air and vapour of nitrite were allowed to enter it in the dark, the slightly convergent beam of the electric light was then sent through the tube from end to end. For a moment the tube was *optically empty,* nothing whatever was seen within it; but before a second had elapsed, a shower of liquid spherules was precipitated on the beam, thus generating a cloud within the tubes. This cloud became denser as the light continued to act, showing at some places a vivid iridescence. The effect was the same when the air and vapour were allowed to enter the tube in diffused daylight. The cloud, however, which shone with such extraordinary radiance in the electric beam, was invisible in the ordinary light of the laboratory.

When dry oxygen was employed to carry in the vapour, the effect was the same as that obtained with air. When dry hydrogen was used as a vehicle the action was also the same. The effect, therefore, is not due to any interaction between the vapour of the nitrite and its vehicle. This was further demonstrated by the deportment of the vapour itself. When it was permitted to enter the experimental tube unmixed with air or any other gas, the effect was substantially the same. Hence the seat of the observed action is the vapour itself. With reference to the air and the glass of the experimental tube, the beam employed in these experiments was perfectly cold. It had been sifted by passing it through a solution of alum, and through the thick double-convex lens of the lamp. When the unsifted beam of the lamp was employed the effect was still the same; the obscure calorific rays did not appear to interfere with the result. When, previous to entering the experimental tube, the beam was caused to pass through a red glass, the effect was greatly weakened, but not extinguished. This was also the case with various samples of yellow glass. A blue glass being introduced before the removal of the yellow or the red, on taking the latter away augmented precipitation occurred along the track of the blue beam. Hence, in this case, the more refrangible rays are the most chemically active.

When the quantity of nitrite vapour is considerable and the light intense, the chemical action is exceedingly rapid, the particles precipitated being so large as to *whiten* the luminous beam. Not so, however, when a well-mixed and highly-attenuated vapour fills the experimental tube. The effect now to be described was obtained in the greatest perfection when the vapour of the nitrite was derived from a residue of the moisture of its liquid, which had been accidentally introduced into the passage through which the dry air flowed into the experimental tube. In this case the electric beam traversed the tube for several seconds before any action was visible; decomposition then visibly commenced, and advanced slowly. The particles first precipitated were too small to be distinguished by a hand lens; and, when the light was very strong, the cloud appeared of a milky blue. When, on the contrary, the intensity was moderate, the blue was pure and deep. In Brücke's important experiments on the blue of the sky and the morning and evening red, pure mastic is dissolved in alcohol, and then dropped into water well stirred. When the proportion of mastic to alcohol is correct, the resin is precipitated so finely as to elude the highest microscopic power. By reflected light such a medium appears bluish, by transmitted light yellowish; which latter colour, by augmenting the quantity of the precipitate, can be caused to pass into orange or red; but the development of colour in the attenuated nitrite-of-amyl vapour, though admitting of the same explanation, is doubtless more similar to what takes place in our atmosphere. The blue, moreover, is purer and more sky-like than that obtained from Brücke's turbid medium.

Space will not admit of our referring to the experiments made on iodide of allyl, iodide of isopropyl, hydrobromic acid, or hydrochloric acid; but the results obtained with hydriodic acid are of so startling and unprecedented a character that we consider it important to give them in Professor Tyndall's own words, as follows: "I have seen nothing so astonishing as the effect obtained on the 28th of October with hydriodic acid. The cloud extended for about 18 inches along the tube, and gradually shifted its position from the end nearest the lamp to the most distant end. The portion quitted by the cloud proper was filled by an amorphous haze, the decomposition which was progressing lower down being here apparently complete. A spectral cone turned its apex towards the distant end of the tube, and from its circular base filmy drapery seemed to fall. Placed on the base of the cone was an exquisite vase, from the interior of which sprang another vase of similar shape; over the edges of these vases fell the faintest clouds, resembling spectral sheets of liquid. From the centre of the upper vase a straight cord of cloud passed for some distance along the axis of the experimental tube, and at each side of this cord two involved and highly iridescent vortices were generated. The frontal portion of the cloud, which the cord penetrated, assumed in succession the forms of roses, tulips, and sunflowers. It also passed through the appearance of a series of beautifully shaped bottles placed one within the other. Once it presented the shape of a fish, with eyes, gills, and feelers. The light was suspended for several minutes, and the tube and its cloud permitted to remain undisturbed in darkness. On reigniting the lamp, the cloud was seen apparently motionless within the tube; much of its colour had gone, but its beauty of form was unimpaired. Many of its parts were calculated to remind one of Gassiot's discharges; but in complexity and, indeed, in beauty, the discharges would not bear comparison with these arrangements of cloud. A friend to whom I showed the cloud, likened it to one of those jelly-like marine organisms, which a film barely capable of reflecting the light renders visible. Indeed no other comparison is so suitable; and not only did the perfect symmetry of the exterior suggest this idea, but the exquisite casing and folding of film within film suggested the internal economy of a highly complex organism. The *twoness* of the animal form was displayed throughout, and no coil, disk, or speck existed on one side of the axis of the tube that had not its exact counterpart at an equal distance on the other. I looked in wonder at this extraordinary production for nearly two hours."

It will be remembered that six or seven years ago Dr. Frankland communicated to the Royal Society some researches on the effect of a diminution of pressure on some of the phenomena of combustion, and deduced therefrom the law that the diminution in illuminating power is directly proportional to the diminution in atmospheric pressure. Further experiments on the nature of the luminous agent in a coal-gas flame have led him to doubt the correctness of the commonly received theory first propounded by Sir Humphry Davy, that the light of a gas flame and of luminous flames in general, is due to the presence of solid particles. It has been found that there are many flames possessing a high degree of luminosity, which cannot possibly contain solid particles, such as the flame of metallic arsenic burning in oxygen, which emits a remarkably intense white light; bisulphide of carbon in oxygen; and especially phosphorus in oxygen.

For these reasons, and for others which the author had stated in a course of lectures on "Coal-gas," delivered in March, 1867, he considered that incandescent particles of carbon are not the source of light in gas and candle flames, but that the luminosity of these flames is due to radiations from dense but transparent hydrocarbon vapours. As a further generalization from the above-mentioned experiments, he was led to the conclusion that dense gases and vapours become luminous at much lower temperatures than aëriform fluids of comparatively low specific gravity; and that this result is to a great extent, if not altogether, independent of the nature of the gas or vapour, inasmuch as he found that gases of low density, which are not luminous at a given temperature when burnt under common atmospheric pressure, become so when they are simultaneously compressed. Thus mixtures of hydrogen and carbonic oxide with oxygen emit but little light when they are burnt or exploded in free air, but exhibit intense luminosity when exploded in closed glass vessels, so as to prevent their expansion at the moment of combustion.

In a communication to the Royal Society, Dr. Frankland has described the extension of these experiments to the combustion of jets of hydrogen and carbonic oxide in oxygen under a pressure gradually increasing to twenty atmospheres. These experiments were made in a strong wrought-iron vessel furnished with a thick glass plate of sufficient size to permit of the optical examination of the flame. The appearance of a jet of hydrogen burning in oxygen under the ordinary atmospheric pressure is well known. On increasing the pressure to two atmospheres, the previously feeble luminosity is very markedly augmented, whilst at ten atmospheres' pressure, the light emitted by a jet about one inch long is amply sufficient to enable the observer to read a newspaper at a distance of two feet from the flame, and this without any reflecting surface behind the flame. Examined by the spectroscope, the spectrum of this flame is bright and perfectly continuous from red to violet.

With a higher initial luminosity, the flame of carbonic oxide in oxygen becomes much more luminous at a pressure of ten atmospheres than a flame of hydrogen of the same size and burning under the same pressure. The spectrum of carbonic oxide burning in oxygen under a pressure of fourteen atmospheres is very brilliant and perfectly continuous.

If it be true that dense gases emit more light than rare ones when ignited, the passage of the electric spark through different gases ought to produce an amount of light varying with the density of the gas; and Dr. Frankland has shown that electric sparks passed, as nearly as possible under similar conditions, through hydrogen, oxygen, chlorine, and sulphurous anhydride, emit light, the intensity of which is very slight in the case of hydrogen, considerable in that of oxygen, and very great in the case of chlorine and sulphurous anhydride. On passing a stream of induction sparks through the gas standing over liquefied sulphurous anhydried in a strong tube at the ordinary temperature, when a pressure of about three atmospheres was exerted by the gas, a very brilliant light was obtained. A stream of induction sparks was passed through air confined in a glass tube connected with a condensing syringe, and the pressure of the air being then augmented to two or three atmospheres, a very marked increase in the luminosity of the sparks was observed, whilst on allowing the condensed air to escape, the phenomena were reversed.

Mr. Huggins, F.R.S., has submitted the light of Comet II., 1868, to spectroscopic examination, and has found it, when examined with a spectroscope furnished with two prisms of 60°, to be resolved into three broad bright bands.

The brightest band commences at about *b*, and extends nearly to F. Another band begins at a distance beyond F, rather greater than half the interval between *b* and F. The third band occurs about midway between D and E. In the two more refrangible of these bands, the light was brightest at the less refrangible end, and gradually diminished towards the other limit of the bands. The least refrangible of the three bands did not exhibit a similar gradation of brightness. These bands could not be resolved into lines, nor was any light seen beyond the bands towards the violet and the red.

The author found this cometic spectrum to agree exactly with a form of the spectrum of carbon which he had observed and measured in 1864. When an induction spark, with Leyden jars intercalated, is taken in a current of olefiant gas, the highly heated vapour of carbon exhibits a spectrum which is somewhat modified from that which may be regarded as typical of carbon. The light is of the same refrangibilities, but the separate strong lines are not to be distinguished. The shading, composed of numerous fine lines, which accompanies the lines appears as an unresolved nebulous light.

On comparing the spectrum of the comet directly in the spectroscope with the spectrum of the induction spark taken in a current of olefiant gas, the three bands of the comet appeared to coincide with the corresponding bands of the spectrum of carbon. In addition to an apparent identity of position, the bands in the two spectra were very similar in their general characters and in their relative brightness. The remarkably close resemblance of the spectrum of the comet to that of the spectrum of carbon necessarily suggests the identity of the substances by which in both cases the light was emitted.

HEAT.—The intense heat of the voltaic arc has been applied by F. P. Le Roux in a most ingenious manner to heighten the brilliancy of the light, and at the same time to increase its steadiness. In applying electric light, the method generally proposed is to direct it into a more or less limited region of space; all which escapes into the opposite region would be lost if it were not collected by reflectors more or less appropriate to the purpose. On the other hand, experience has proved that the voltaic arc is prone to irregular displacements, consequent upon inequalities in the cohesion of the charcoal, impurities contained in it, and above all, the slightest agitation of the air. The most luminous portions of the charcoal electrodes being the surfaces between which the arc arises, these surfaces are inclined sometimes in one direction and sometimes in another, by reason of the displacement which the arc undergoes, the result being a considerable variation in the effect of light produced by the latter in any determinate region. M. Le Roux argued, in the course of his investigation, that if there could be placed on the opposite side to that towards which the light was to be directed, and in proximity to the arc, some body capable of reflecting back in a luminous form the enormous number of radiations thrown upon it by the electrodes and the arc itself, these radiations would be more profitably utilized than by any other method, the arc being at the same time protected by a sort of screen, annulling in an almost hemispheric region all the above-mentioned disturbing causes.

The substance chosen for such a purpose should be at the same time a bad conductor of heat, and possessed of great powers of radiation, conditions fulfilled to a great extent by lime, magnesia, and earthy oxides in general. The experiment was first effected with cylinders of magnesia compressed according to the process of M. Caron, and manufactured for purposes of oxyhydric illumination. By placing the base of one of these cylinders, whose diameter is about 8 millimetres, at a short distance from the charcoal points of an electric lamp, in such a way that the magnesia may be, as it were, licked up by the voltaic arc, it will assume an incandescence equal to that of the most luminous portion of the charcoal. At the same time the light acquires remarkable constancy from the fixity of the arc, which may be drawn to greater length than in ordinary cases, because as the magnesia forms a screen and maintains the elevation of the temperature, the chances of the arc being broken are greatly diminished.

The magnesia may thus be kept in contact with the voltaic arc for more than an hour without sufficient consumption to cause any apparent change in the conditions of the experiment; its surface becomes hollow during the first few moments, but if the bar of this substance is kept fixed, the power of the arc abating at a very slight distance, it will no longer be consumed. Another kind of alteration will, however, ensue. The magnesia will imbibe the silicious vapours emitted by the voltaic arc, and combine with them in a sort of glass, which, when cold, is of a pale greenish hue, and extremely hard. This fact is disadvantageous, inasmuch as it greatly diminishes the irradiating power of the magnesia, and renders the production of a commercial pure carbon in an appropriate condition for the purpose of electric illumination still more desirable. The arrangement of a brilliant voltaic arc between two pencils of charcoal, and in the presence of magnesia or any other earthy oxide, would constitute one of the most beautiful sources of light possible to realize.

M. Kindt has made known the nature of the phosphorescence developed by heat in the three minerals, chlorophane, Estremadura phosphorite, and the green fluor spar. He has analyzed the light emitted: the first is a simple green; the second is a yellow-tinted light, composed of green, yellow, and red; and the third gives two black rays, the one in the green, and the other near the orange.

M. Becquerel has invented an electric pyrometer for the measurement of high temperatures. Metallurgists will probably find this application very advantageous. To solve the problem of the commercial application of a thermo-electric current as a pyrometer, it was necessary to make a thermo-electric couple with two unalterable metals, resisting the highest temperatures, and then to establish a graduated table. As to the practical introduction of the pyro-electric couple, it is easily made. A table of sines has been specially constructed for these observations.

ELECTRICITY.—A new arrangement for furnishing currents of electricity has been made known by M. Ney. It is composed as follows:—1. A vessel filled with solution of chloride of ammonium, containing a plate of amalgamated zinc. 2. A porous cylinder filled with carbonate of copper, into which a plate of copper plunges. To maintain the battery in action, it is only necessary to add solid chloride of ammonium from time to time. In military telegraphy, where the pile should be capable of transport, the outer vessel might be filled with sand saturated with a solution of chloride of ammonium in the place of the solution. This arrangement recommends itself on the score of cheapness, for native carbonate of copper answers sufficiently well, and it likewise only requires attention while in actual use. Carbonate of copper is insoluble in a solution of chloride of ammonium, but upon closing the current, the chloride is decomposed into hydrochloric acid and ammonia; the hydrochloric acid collects at the zinc pole, the ammonia at the copper. The carbonate of copper becomes soluble, and its reduction gives rise to a secondary current having the power of a Daniells element. This form of battery is perfectly constant.

At a meeting of the French Academy some time ago, M. Sidot showed several samples of iron pyrites possessing magnetic polarity, obtained by passing a current of hydrosulphuric acid over the magnetic oxide. At that time he stated that the direction of the polar axis appeared to be in relation to the position of matters at the moment of their formation with reference to the magnetic axis of the globe. M. Sidot has now tested his supposition further by examining the behaviour of the magnetic oxide of iron, to ascertain whether it suffered the same physical modifications, when placed in the same conditions, as magnetic pyrites, and whether the polarity was produced by the earth by removing all causes foreign to terrestrial action. When a tube of refractory clay is placed parallel to the magnetic needle, in a furnace free from iron, and in the tube a platinum boat filled with colcothar, which is heated to bright redness in a current of air for an hour, the result, after cooling, is a strongly agglomerated grey oxide, possessed of magnetic polarity. The extremity of the oxide turned towards the north is a south pole; it energetically repulses the pole of a magnetic needle pointing to the north of the earth. A magnetic oxide is likewise obtained by calcining colcothar in a platinum crucible. The upper extremity of the mass presents a pole opposed to the south pole of the globe, and the lower extremity an opposite pole. To obtain masses possessed of greater magnetic polarity a different disposition was made.

A piece of iron plate in the form of a tube, was suspended in a clay tube placed vertically in a furnace traversed by a very rapid current of air, and heated to bright redness for the time necessary for the complete oxidation of the iron. Tubes of oxide were thus obtained possessed of magnetic polarity, and strongly repelling the poles of the magnetic needle. The polarity is always dependent upon the position of the iron plate. The magnet produced in this way was replaced in the furnace, reversed, and heated in the same conditions of temperature as before for one hour; after cooling, the poles were found to be reversed; that pole which is formed at the upper extremity is always similar to the north pole of the earth.

12. ZOOLOGY—ANIMAL MORPHOLOGY AND PHYSIOLOGY.

(*Notices of Works recently published and Transactions of Societies.*)

The alleged Failure of Natural Selection in the case of Man.—A writer in a recent number of 'Fraser's Magazine' endeavours to point out that although there is a struggle for existence of a more or less intense kind, between different *races* and *nations* of men, yet that between man and man in a civilized condition there is no such struggle—the weak being protected, and the feeble inheriting wealth which they have not won. Thus, the fittest do not survive contends this writer, and the law of selection is so far interfered with as to fail, and indeed we may expect degeneracy rather than improvement in civilized men. The 'Spectator,' in one of its clever articles—written, however, in this case with a hasty and mistaken idea of the question at issue—accepts the view propounded by the writer in 'Fraser' in part, but, making use of the mysterious term "supernatural selection," asserts that a new source of benefit is opened up to man by the cultivation of his moral nature, which counterbalances any attendant evils. The error in this view of the case arises from a neglect of the fact that civilized man is a social animal, in a truly zoological sense. There is no struggle for existence between the various bees of a hive, nor among polyps of a polypidom: the struggle is between hive and hive, and polypidom and polypidom. So with the communities of civilized men—the struggle is between one society and another, whatever may be the bond uniting such society: and in the far distant future we can see no end to the possible combinations or societies which may arise amongst men, and by their emulation tend to his development. Moral qualities, amongst the others thus developed in the individual necessarily arise in societies of men, and are naturally selected, being a source of strength to the community which has them most developed: and there is no excuse for speaking of a failure of Darwin's law or of "supernatural" selection. We must remember what Alfred Wallace has insisted upon most rightly—that in man, development does not affect so much the bodily as the mental characteristics; the brain in him has become much more sensitive to the operation of selection than the body, and hence is almost its sole subject. At the same time it is clear that the struggle between man and man is going on to a much larger extent than the writer in 'Fraser' allowed. The rich fool dissipates his fortune and becomes poor; the large-brained artizan does frequently rise to wealth and position; and it is a well-known law that the poor do not succeed in rearing so large a contribution to the new generation as do the richer. Hence we have a perpetual survival of the fittest. In the most barbarous conditions of mankind, the struggle is almost entirely between individuals: in proportion as civilization has increased among men, it is easy to trace the transference of a great part of the struggle little by little from individuals to tribes, nations, leagues, guilds, corporations, societies, and other such combinations, and accompanying this transference has been undeniably the development of the moral qualities and of social virtues.

MORPHOLOGY.

The Early Stages of Development in Vertebrates.—Dr. Wilhelm His, professor at Basel, and a worthy pupil of the great pioneers of embryology, Rathke and Von Bär, has recently published a valuable work on the above subject, illustrated with twelve plates. The principal point upon which Dr. His insists is the presence of two germinal elements—the principal or primary germ, and the subordinate or secondary germ. From the first proceed the most essential tissues, *viz.* the nervous, muscular, and epithelial, whilst from the second arise the skeletal and nutrient structures, *viz.* connective tissues, cartilage, bone, and the vascular system. Dr. His traces out fully the development of each of these two portions, which he distinguishes in the early embryo, and describes how they grow the one into the other, eventually producing a most complex interlacement of parts. He also points out that the development of the secondary germ is very much affected by mechanical conditions, and endeavours to show how the form and relation of parts is thus brought about in the embryo. The perivascular lymph-spaces of the brain discovered by Dr. His are shown to arise from the intrusion of blood-vessels formed by the secondary germ into spaces excavated in the primary germ. A comparison of the two extremities of the developing vertebrate is also made, and some curious similarities in opposite parts alluded to. Professor His is so distinguished an observer, that this volume cannot fail to command great attention both in this country and abroad.

New Species of Tasmanian Wolf.—Of all mammals there is perhaps not one existing which is so truly interesting, so deeply significant of the history of the development and geographical distribution of mammals, as the marsupial dog. Mr. Gerard Krefft, of the Australian Museum at Sydney, has lately obtained from his assistant, Mr. Masters, no less than twenty-six skulls of this rare animal, which is found only in Tasmania. Two of these skulls belong to a new species, distinguished by its shorter muzzle and other characters, for which Mr. Krefft proposes the name *Thylacinus breviceps.* The existence of a second Thylacine has been known to old residents in Tasmania for years past, as they were in the habit of distinguishing the two kinds by the names of greyhound- and bulldog-tiger. A fuller account of the collection of skulls is promised for a future number of the Annals of Natural History.

Transporting Fish alive.—Mr. Moore, the curator of the Liverpool Free Museum, has succeeded in importing some living fish from the River Plate, the first live fish that he has received from south of the Equator. Some English fish sent out by the same captain arrived safely, and he left Liverpool on the 10th of October with another series of fish. They were sent out and imported in a common fish-globe, suspended like a cabin-lamp in gimbals. There are now exhibited in the Liverpool Museum, two Catfish, three species of Pomotis, two of Cyprinus, four Axolotls, and a *Proteus,* that were imported from New York by the same method. Dr. Perceval Wright, on his return journey from the Seychelles last autumn, succeeded in bringing a small Cyprinoid, *Haplochilus,* as far north as Paris. He found that the motion in the railways was by far the hardest thing to contend with, and indeed his fish were absolutely jolted to death, the churning of the water preventing respiration.

Occurrence of the Ground-Fluke in England.—A soft dingily-coloured little creature, not an inch long and very much like a small slug, has lately excited a little attention by its discovery in England. Sir John Lubbock found specimens of it in his garden in Kent, and mentioned the fact to the Linnean Society in September last, and Mr. Houghton has seen it in Shropshire. Originally it was discovered by Müller in Denmark, and named by him; it has since been observed by Dugés in France, and by Fritz Müller, and Moll in Germany. In 1867, Mr. Ray Lankester drew attention to it in the 'Popular Science Review,' and expressed a belief that it would be found in England; shortly after this he received four living specimens from Mr. Edward Parfitt, of Exeter. It appears that its occurrence in England had been recorded some years since by the Rev. Leonard Jenyns. Sir John Lubbock and Mr. Houghton say that this ground-fluke is a true *Planaria* Those, however, who have studied the Turbellarian worms will know that the genus *Planaria* must have a very much more restricted character, and cannot be made conveniently to include this form, for which the genus *Geoplana* is usually adopted. In South America and Ceylon there are other forms of land-flukes of larger size and very brilliant colour. The English species differs considerably from these, but its anatomical details are not known. It is almost impossible to dissect specimens, and they are not sufficiently transparent for the microscope. The ground-flukes, however, undoubtedly belong to that section of the short aproctous Turbellaria, in which the intestine is arborescent.

American Polyzoa.—Mr. Alpheus Hyatt has published, in the Proceedings of the 'Essex Institute' of Salem, Mass., a very detailed and valuable account of the fresh-water Polyzoa (Phylactolæmata) of that part of the North American continent. A large portion of the work is occupied with anatomical descriptions, which are illustrated in plates executed on a black ground; a style which appears to be a favourite one in the States, but which we think is very inferior to a well-shaded drawing of the ordinary description. Here is a statement which we assuredly cannot accept, "It therefore becomes necessary to alter the commonly received nomenclature, and to denominate the attached end of a Polyzoön the anterior, the free end the posterior, the anal side the dorsal, and the opposite or so-called hæmal side the ventral." It is not at all "necessary" to use the objectionable terms "anterior," "dorsal," and their converse, and they certainly can have no strict meaning, but only a conventional one. The term "Saccata" is proposed for the Mollusca, and has been endorsed by Mr. E. S. Morse in a paper on the classification of those animals. Saccata is not by any means an appropriate term; for the Infusoria, the Cœlenterata, and many worms are quite as distinctly sack-like as the mollusca, in fact, all animals are sacks. The following genera are described: *Fredericella* with three species, *Plumatella* with four species, *Pectinatella* with one species, *Cristatella* with one species. Many details of interest and importance are given in the anatomical descriptions of the genera; and the whole work is executed with very great care and methodical treatment.

The Glass-rope Sponge.—This interesting organism has, we think, at last come to the climax of its celebrity, and will soon sink into more or less of obscurity, for its secret has been discovered. Professor Lovén was right in supposing, from the study of a sponge which he called *Hyalonema boreale*—but which should not be put in the genus Hyalonema—that the long tuft of glassy fibres constituting the so-called axis of *Hyalonema* is the pedicle by which it is fixed in the sea bottom, and that the sponge grows on the top of this. Professor Perceval Wright, of Dublin, went last October to Lisbon for the purpose of dredging the European Glass-rope, discovered some two years since by Professor Barboza de Bocage, and he has succeeded in bringing it up from the deep sea-valley in which it grows in such a condition as to leave no doubt in his mind that it lives with the axis inserted in mud, as a sort of stalk. Dr. Carpenter and Professor Wyville Thompson too, on a recent dredging expedition off the west of Ireland, have brought up *Hyalonema* in the same way. Dr. Wright has no doubt that Max Schultze is right about the parasitic nature of the coral, which *sometimes* encrusts the axis of Hylomena, which is a true sponge. Dr. Gray, however, retains his opinion that the axis is the work of the coral, and that the sponge on the end of it is parasitic. In a recent article on a form of sponge allied to Euplectella (the beautiful crab's-nest sponge), which is really a close ally of Hyalonema, Dr. Gray points out that the long spicules in that form may possibly have been inserted in the mud as a support—as in Hyalonema, yet he still regards the one as sponge, the other as coral.

PHYSIOLOGY.

Intellectual Work and the Temperature of the Head.—Dr. J. S. Lombard, by means of an exceedingly delicate thermo-electric apparatus, has made some highly interesting experiments on the influence of cerebral activity on the temperature of the head. He finds: 1st. That in the state of cerebral repose (during night) the temperature of the head varies very rapidly and frequently. 2nd. The changes are very small, scarcely reaching the hundredth of a degree centigrade. 3rd. In proportion as the activity of the brain increases, the temperature is found to rise. 4th. Any cause attracting the attention (a sound, the sight of an object or a person) produces an elevation of temperature. 5th. Very active intellectual work produces a much more marked elevation of temperature than in the preceding cases. It does not, however, exceed a twentieth of a degree centigrade. 6th. An emotion, or reading aloud of anything of great interest, causes an elevation of temperature. It is not the movement of the heart or of the muscles which under these circumstances causes a rise in the temperature of the head. 7th. During very arduous intellectual work, the temperature of the limbs falls even as much as a quarter or half a degree centigrade; in part, no doubt (but only in part), owing to the immobility of the body. 8th. It is in the region of the occipital protuberance that the elevation of temperature had its chief seat in the preceding experiments.

It will be interesting to consider the bearing of these phenomena on the Conservation of Force. It is apparently clear that intellectual activity—thought—is a force totally distinct from, although associated with, the mode of motion known as "heat," for both, it appears, increase in activity simultaneously. More than this it were not prudent to say at present, but it appears that here we have the first approach to a better understanding between the relations of "mind and matter," a subject upon which so much has been said speculatively, and so little done experimentally.

Effects of Rowing upon the Circulation.—Dr. Fraser, of Edinburgh, has been carefully examining the effects of rowing on the pulse, by means of the sphygmograph. Dr. Fraser had the opportunity of recording the "sphygmograms" of a crew of healthy men on several occasions, before leaving the boat-house and immediately after return. The tracings show clearly that an extremely large quantity of blood is being circulated with great rapidity—a condition of the circulation which would be considered essential on other grounds for the continuance of prolonged and severe muscular exertion. It is obvious that in the great majority of functional and organic diseases of the vascular system such a condition could not possibly be maintained. The subjects of these diseases are therefore completely incapacitated from *violent* rowing exercise, and cannot be in a position to be injured by it. It is possible that the presence of incipient forms of disease of the vascular system may not altogether prevent such exercise from being undertaken; but Dr. Fraser believes that all such diseases may be detected by the use of the sphygmograph in time to prevent further mischief, the examination being made immediately before the boat is entered, and a few minutes after a moderate pull has been indulged in. The effects produced by rowing on the circulation do not differ from those of many other forms of muscular exercise.

The Physiological Effect of Snake-bite.—Dr. Joseph Jones, of New York, has made some interesting observations on the effects of snake-bite. He used the American snake called the Copperhead, and subjected several dogs, at various times, to its bite. In some cases the dogs died; in others they recovered. In all cases Dr. Jones observed carefully the microscopical condition of the blood, and in cases of death made *post-mortem* examinations. Dr. Jones observes, in one case, "The blood from the swollen infiltrated cellular structures of the head and nose where the snake inflicted the severest bite presented a peculiar appearance: thousands of small acicular crystals were mingled with the altered blood-corpuscles, and as the bloody serum and effused blood dried, the blood-corpuscles seemed to be transformed into crystalline masses, shooting out into crystals of *hæmatin* (hæmato-crystallin ?) in all directions. The blood-vessels of the brain were filled with gelatinous coagulable blood, which presented altered blood-corpuscles and acicular crystals." Dr. Halford, about two years since, figured and described in the 'Quarterly Journal of Microscopical Science,' the microscopic appearance of the blood of a dog killed by snake-bite. He particularly drew attention to the enormous increase in the number of white corpuscles in the blood. Dr. Joseph Jones concludes that the special toxic effect of the poison of the snake is due to its destructive effects on the red blood-corpuscle. Mr. Frank Buckland, in a recent note on this subject, in his highly interesting journal, 'Land and Water,' says that the snake's poison seems to "curdle" the blood. It may very well be questioned how far it is right to attribute this condition of the blood to the *direct* action of the snake's poison. Should we attribute the buffy coat of the blood of a fever-patient to the *direct* action of the fever-poison? or the increase of white corpuscles after blood-letting to some specific poison in the lancet?

NEW BOOKS.

The Record of Zoological Literature of 1867.—This, the fourth volume of the 'Record,' is issued in three parts, in accordance with a suggestion of Dr. Albert Günther, the editor, so that naturalists can purchase what is most interesting to them without being encumbered by other matter. The Vertebrates form one part; the Insects, Myriopods, and Arachnids another; and the third contains the Mollusca, Crustacea, Rotifera, Annelida, Scolecida, Echinodermata, Cœlenterata, and Protozoa. Dr. Günther, Professor Newton, Mr. W. S. Dallas, Dr. von Martens, and Professor E. P. Wright are the Recorders, and have performed their task in the same satisfactory manner as heretofore. A grant of 100*l.* was given by the British Association at Dundee and at Norwich to assist in the yearly publication of the 'Record,' and it is hoped that all working naturalists and also the patrons of science will procure this work and make good use of it. It is well known that Mr. Van Voorst the publisher is continuing this work, not for profit, which *he* will probably never realize, though his successors may, but we congratulate him more heartily upon the laurels which he will reap as a lover and patron of Zoological Science, than we should do if we thought he was about to benefit materially by his work.

Bristol Naturalist's Society.—This excellent and flourishing Society publishes its proceedings from time to time, and at the end of the year they form a neat little volume, which we now have before us. Mr. Lant Carpenter has for some time edited the reports of the Society, but we regret to see he has now been obliged to retire on account of the occupation of his time. In glancing through the pages of the reports, we came upon a paper by Mr. Groom-Napier on the Dodo, in which it is stated that there is an original picture of that obese bird in the Ashmolean Museum. This is we believe an error. In the University Museum there is the celebrated head, and recently a skeleton has been set up by the talented curator of the anatomical collection—Mr. Charles Robertson —from bones lately obtained in the Mauritius. It is rather amusing to read of Mr. Groom-Napier and some of his fellow-naturalists maintaining that the Dodo cannot be rightly associated with the pigeons. A careful study of its osteology would or ought to bring them round to the opinion of the chief zoologists of the day.

The Anatomy and Physiology of Vertebrates, Vol. III.*—Professor Owen has now completed his great work, but it reaches us too late to do it justice in the present number.

The Royal Medals of the Royal Society.—One of these medals has this year been awarded to Alfred R. Wallace, the distinguished traveller and philosophical zoologist, who is not unknown to the readers of this Journal.† It was particularly in view of his researches on the distribution of animals which led him to frame the theory of the origin of species by modification and descent, placed before the world simultaneously with Mr. Darwin's, that Mr. Wallace has received this high but well-earned recognition of his merits. The other Royal Medal was given to Dr. Salmon, of Trinity College, Dublin.

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* Longmans.

† See his papers on "Ice-marks in North Wales," "Creation by Law," and "On the Migrations of the Polynesians," all published in vol. vi. of the Journal.

THE ROYAL MICROSCOPICAL SOCIETY.

We have received two circulars relative to a change which is about to be made in the mode of publishing the Transactions of the above Society. It appears that in future they are no longer to be published under the auspices of the Society in the well-known 'Quarterly Journal of Microscopical Science,' edited by Dr. Lankester and his son, but in a new monthly journal to be issued by Mr. Hardwicke and edited by Dr. Lawson. We shall be glad to see both these journals thrive. Of the continued success of the old journal we have no doubt, more especially as the wholesome competition about to be created will stimulate editors and publishers. Of the new one we can of course say nothing at present. Our object in referring to this circumstance is, however, not so much to direct the attention of microscopical observers to it, as to express the opinion that a Society which has been at the trouble and expense of obtaining a Royal Charter of incorporation, and which has changed its members into "Fellows," should publish its own transactions independently of any periodical, however respectable and useful it may be. Whilst the Society was content to pursue its labours unostentatiously, and when all the members were charged the moderate annual subscription of a guinea, the publication of its transactions in some periodical was justifiable, but after the changes which have been made (whether they were proper or not is a matter of taste), we think it hardly consistent that the transactions should serve as a shuttlecock for rival publishers. If our anticipations should not be fulfilled, and it should be found that the circle of microscopical readers is not sufficiently extended to support a second journal, then the members will have to be referred back to the old journal, or to some new literary *protégé* of the council, and any one desirous of binding the Proceedings continuously, and placing them for reference upon his shelves, must take with them whatever may appear in the journal in which they have been published. But there is even a more serious objection than this. Recent events elsewhere have shown that connections of this kind are not conducive to good feeling amongst the members of the council of a learned society, and we should indeed be sorry to see dissatisfaction arise in this one, which might necessitate a "Committee of Inquiry," accompanied as such proceedings usually are, by all the amenities of a scientific controversy. We have no desire to place any obstruction in the way of the council, but it is obviously our duty to mention these matters before the trouble has arisen. It appears to us that they have made more than one mistake. The charter of incorporation and change of names has in no wise elevated the Society, or its members; but has entailed an expenditure which has not alone necessitated an increased subscription to new members (a double tariff in fact), but has so reduced the funds as to render it a matter of difficulty to pay the postage on the Transactions. The publication of those in the old journal a day longer than was necessary was another mistake; the transference to a rival, a third. The Council should charge all members alike, publish their own Transactions, and limit their moral responsibility to the record of what passes at their meetings. If these hints pass unheeded now, the time will come when they will be remembered.

Quarterly List of Publications received for Review.

1. On the Anatomy of Vertebrates. Vol. III. Mammals. By Richard Owen, F.R.S., &c. 614 *Woodcuts.* *Longmans & Co.*

2. A Practical Treatise on Metallurgy, adapted from the last German Edition of Professor Kerl's Metallurgy. By Wm. Crookes, F.R.S., and E. Röhrig, Ph.D. 207 *Woodcuts.* *Longmans & Co.*

3 Essays on Physiological Subjects. By Gilbert W. Child, M.D., F.L.S., &c. *Longmans & Co.*

4 Notes on the Metals. Being a Second Series of Chemical Notes for the Lecture Room. By Thomas Wood, Ph.D., F.C.S. *Longmans & Co.*

5. Fownes's Manual of Elementary Chemistry. Edited by Henry Bence Jones and Henry Watts. Tenth Edition. 193 *Engravings.* *Churchill & Sons.*

6. The Elements of Heat and of Non-Metallic Chemistry. 74 *Woodcuts.* By Frederick Guthrie, B.A. Lond., &c. *John Van Voorst.*

7. Appendix to the Manual of Mollusca of S. P. Woodward, A.L.S., containing such Recent and Fossil Shells as are not mentioned in the Second Edition of that Work. By Ralph Tate, A.L.S., F.G.S. *Virtue & Co.*

8. Travels in the East Indian Archipelago. By Albert S. Bickmore, M.A., F.R.G.S., &c. *Copiously Illustrated.* *John Murray.*

9. A Treatise on the Action of Vis Inertiæ in the Ocean. By W. L. Jordan, F.R.G.S. *Longmans & Co.*

PAMPHLETS AND PERIODICALS.

On the Regenerative Gas Furnace, as applied to the Manufacture of Cast Steel. By C. W. Siemens, F.R.S. *London: Harrison & Sons.*

On Puddling Iron. Same Author. *London: Newbery & Alexander.*

On Geological Time, and the Probable Date of the Glacial and Upper Miocene Period. By James Croll.

Notes on the Chemical Geology of the Gold Fields of California. By J. Arthur Phillips.

The Liverpool Medical and Surgical Reports.
London: Churchill. Liverpool: Holden.

New Pages of Natural History. Meteors and Meteorites. Caves and their Contents. Fossil Fish. By H. P. Malet. *T. C. Newby.*

Publications of the Smithsonian Institution, Washington:—

Observations on the Polyzoa. 9 *Plates.* By A. Hyatt.

Observations on the Metamorphosis of Siredon into Amblystoma. By O. C. Marsh, Yale College.

Results of Meteorological Observations made at Marietta, Ohio, between 1826 and 1859 inclusive. By S. P. Hildreth. Reduced and discussed by C. A. Schott.

Physical Observations on the Arctic Seas. By Isaac J. Hayes, M.D. Reduced and discussed by C. A. Schott.

Francis Peabody.

Smithsonian Report for 1866.

A Guide to the Study of Insects, and a Treatise on those Injurious and Beneficial to Crops. By A. S. Packard, jun., M.D.

On the Source of Light in Luminous Flames. Dr. Frankland, F.R.S.

The Rainfall in Devonshire during 1866-1867. By W. Pengelly, F.R.S., &c.

On the Condition of Some of the Bones found in Kent's Cavern, near Torquay, Devonshire. Same Author.

The Literature of Kent's Cavern, Torquay, prior to 1859. Same Author.

The History of the Discovery of Fossil Fish in the Devonian Rocks of Devon and Cornwall. Same Author.

The Submerged Forest and Pebble Ridge of Barnstaple Bay. Same Author.

Third Report of the Committee for Exploring Kent's Cavern. (W. Pengelly, Reporter.)

The Science of Man: a Bird's-eye View of the Wide and Fertile Field of Anthrology. By Charles Bray. *Longmans & Co.*

Twenty-second Annual Report of the Board of Trustees of the Public Schools of the City of Washington.

Notes on Books. Being an Analysis of the Works published during each Quarter by *Longmans & Co.*

The Geological Magazine.

The London Student.

The Popular Science Review.

The Westminster Review.

The American Naturalist, Salem, Massachusetts.

The Public Health.

PROCEEDINGS OF LEARNED SOCIETIES, &c.

Transactions and Proceedings of the Royal Society of Victoria.

Proceedings of the Bristol Naturalist's Society. Edited by W. L. Carpenter, B.A., B.Sc.

Journal of the Historical and Archæological Association of Ireland. *Dublin: McGlashan.*

Proceedings and Papers of the Kilkenny and South-East of Ireland Archæological Society. *Dublin: McGlashan.*

Journal of the Transactions of the Victoria Institute.

Transactions of the Clinical Society of London.*

Proceedings of the Liverpool Literary and Philosophical Society.

Proceedings of the Royal Institution of Great Britain.

" " Royal Society.

" " Royal Astronomical Society.

" " Royal Geographical Society.

" " Geological Society.

" " Zoological Society.

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